LONDON-WEST MIDLANDS ENVIRONMENTAL STATEMENT

Volume 5 | Technical Appendices

CFA7 | Colne Valley

Water resources assessment (WR-002-007)

Water resources

November 2013

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Department for Transport

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1 Introduction

1.1 Structure of the water resources and flood risk assessment appendices

1.1.1 The water resources and flood risk assessment appendices comprise three parts. The first of these is a route-wide appendix (Volume 5: Appendix WR-001-000).

1.1.2 Specific appendices for each community forum area (CFA) are also provided. For the Colne Valley (CFA7) these are:

- a water resources assessment (i.e. this appendix); and
- a flood risk assessment (Volume 5: Appendix WR-003-007)

1.1.3 Maps referred to throughout the water resources and flood risk assessment appendices are contained in the Volume 5, Water Resources and Flood Risk Assessment Map Book.

1.2 Study area

1.2.1 The study area for this CFA covers approximately 5.7km of the Proposed Scheme in the London Borough of Hillingdon (LBH) and the South Buckinghamshire, Chilterns and Three Rivers District Councils. The area extends from Harvil Road in the south, over the Colne Valley lakes to the M25. The Proposed Scheme will pass through the parishes of Denham and Chalfont St Peter.

1.2.2 The Proposed Scheme will cross under the realigned Harvil Road (see Map CT-06-019, Volume 2, CFA7 Map Book). A viaduct through the Colne Valley, approximately 3.4km long, will cross over the GUC (, the Mid Colne Valley site of special scientific interest (SSSI), the River Colne, a number of other lakes including Harefield No 2 Lake used by the Hillingdon Outdoor Activity Centre, and the A412 Denham Way (North Orbital Road) (see maps CT-06-019 and CT-06-021, Volume 2, CFA7 Map Book). On leaving the viaduct the route will be on embankments and then cutting before passing into the southern portal of the Chiltern tunnel just before it crosses beneath the M25.

1.2.3 The spatial scope of the assessment was based upon the identification of surface water and groundwater features within 1km of the centre line of the route, except where there is clearly no hydraulic connectivity. For surface water features in urban areas, the extent was reduced to 500m. Outside of these distances it is unlikely that direct impacts upon the water environment will be attributable to the Proposed Scheme. Where works extend more than 200m from the centre line, for example at stations and depots, professional judgement has been used in selecting the appropriate limit to the extension in spatial scope required. For the purposes of this assessment this spatial scope is defined as the study area

1.2.4 The main environmental features of relevance to water resources include:

- the wide floodplain valley of the River Colne and a tributary, the Newyears Green Bourne;

- the Mid Colne Valley SSSI (see Map EC-01-011 and EC-01-012 (Volume 5, CFA7 Ecology Map Book). This SSSI consists of several lakes between the River Colne and GUC and part of the River Colne;
- flooded gravel pits and the GUC which both occupy parts of the valley floor;

1.2.5 the Cretaceous Chalk, a Principal aquifer (see Map WR-02-007, Volume 5, Water Resources and Flood Risk Assessment Map Book); and

- licensed private and public water supply (PWS) groundwater abstractions and associated source protection zones (SPZ).

1.2.6 Key environmental issues relating to water resources include:

- permanent realignment of the River Colne and Newyears Green Bourne;
- construction of a viaduct pier in the existing River Colne and a number of piers through some of the lakes within the Mid Colne Valley, including Harefield No. 2 Lake, Savay Lake, Korda Lake and Long Pond;
- potential impacts on groundwater quality as a result of construction activities associated with tunnelling, piling and retaining walls; and
- potential impacts on groundwater flow towards PWS located close to the route due to the piles to be constructed in the aquifer to support the viaduct.

1.2.7 Where a residual impact or mitigation for water resources has a consequent effect on ecology, this is discussed further in Volume 2, CFA Report 7, Section 7.

2 Stakeholder engagement

2.1.1 Discussions have been held with the following stakeholders to inform the water resources assessment:

- the Environment Agency with regard to abstraction licenses and river diversions;
- the Canal & River Trust (formerly British Waterways) with regard to the Grand Union Canal (GUC);
- London Borough of Hillingdon (LBH) with regard to the Newyears Green landfill;
- Affinity Water, the PWS abstractions and the water resources management plan within this and the adjacent areas (CFA6 and CFA8); and
- a private abstraction licensee where the consultations have comprised informing the private licensees and requesting further information in a questionnaire to more accurately assess and understand any potential risks to the private abstraction.

3 Baseline data

3.1 General

3.1.1 The following sub-sections provide a current description of water resources within the study area including surface water and groundwater features.

3.1.2 All water bodies in this area fall within the Colne catchment of the Thames River Basin District as defined under the Water Framework Directive[1] (WFD) and are covered by the River Basin Management Plan[2] (RBMP).

3.2 Surface water

3.2.1 All surface water features within 1km of the route are presented in Table 1.

3.2.2 The current surface water baseline and water features with codes listed in Table 1 are shown in Map WR-01-008 (Volume 5, Water Resources and Flood Risk Assessment Map Book). The map reference is in one of two forms. If the feature has a specific reference number then this is provided (e.g. a surface water crossing will be referenced as SWC-CFA07-01). If the feature has no specific reference its location on a specific map is provided (e.g. WR-01-008, D6) where D6 is a grid reference using the map specific grid.

3.2.3 The surface water features are based on the Environment Agency's Detailed River Network (DRN) with the addition of water bodies noted on the Ordnance Survey's (OS) 'OS VectorMapDistrict'

3.2.4 The area is semi-rural with large areas of surface water in the Colne Valley.

3.2.5 A map of the area can be found in Figure 1, illustrating the location of the surface water features listed in Table 1 that are likely to be impacted by the Proposed Scheme.

[1] European Parliament and European Council (2000). Water Framework Directive - Directive 200/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, Strasbourg, European Parliament and European Council.
[2] Environment Agency (2009). River Basin Management Plan, Thames River Basin District.

Table 1: Surface water features within 1km of the route in CFA7

Water feature	**Location description (Volume 5, Water Resources and Flood Risk Assessment Map Book map reference)**	**Watercourse classification[3]**	**WFD water body and current overall status**	**WFD status objective (by 2027 as in RBMP)**	**Receptor value[4]**	**Q95[5] (m^3/s)**	**Catchment area at crossing (km^2)**	**Notes**
Four unnamed field drains	Uxbridge Golf Course, near oil depot, will be 300m south of the route.	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	The drains are not connected to other surface water features in the area.
Newyears Green Bourne	Located near Dews Farm and Harefield No. 2 lake (SWC-CFA7-02)	Main river	No status class in RBMP – assumed status Poor	No status class in RBMP – assumed status Good potential	High	0.01	5.0	Newyears Green Bourne flows from the north (in the adjacent CFA6) in a culvert, and then changes to a south-west direction from Highway Farm before crossing the route near Dews Farm (SWC-CFA7-02). This small watercourse enters Harefield No. 2 Lake to the south of the route at Dews Farm. The lake discharges into another watercourse which flows south, before joining the Fray's River near Denham Lock.
Three unnamed lakes	Part of Fray's Valley Local Nature Reserve. Will be between 370m and 1km south of the route (CFA07-P01).	Ordinary watercourse	No status class in RBMP – assumed status. Poor	No status class in RBMP – assumed status. Good potential	High	Not applicable	Not applicable	There are also four smaller ponds near the lakes and small field drains. The lakes are part of the Fray's Valley Local Nature Reserve. It is assumed that all lakes are hydraulically linked to the system of drains which flow southwards towards the Fray's River.

[3] Water-feature classifications: Section 113 of the Water Resources Act 1991 defines a main river as a watercourse that is shown as such on a main river map. Section 72 of the Land Drainage Act 1991 defines an ordinary watercourse as 'a watercourse that is not part of a main river'. Section 221 of the Water Resources Act 1991 defines a watercourse as including 'all rivers and streams, ditches, drains, cuts, culverts, dikes, sluices, sewers (other than public sewers) and passages through which water flows'. Main rivers are larger rivers and streams designated by the Department for Environment, Food and Rural Affairs (Defra) on the main river map and are regulated by the Environment Agency

[4] For examples of receptor value, see Table 43 in the Scope and Methodology Report (SMR) Addendum, Volume 5: Appendix CT-001-000/2.

[5] Derived from National River Flow Archive data and catchment areas calculated using the Flood Estimation Handbook - Centre for Ecology and Hydrology, (2009) Flood Estimation Handbook (FEH) CD-ROM Version 3.0. Q95 is the flow which is exceeded for 95% of the time (i.e. it is a low flow and the river will only have flows less than this for 5% of the time).

Water feature	Location description (Volume 5, Water Resources and Flood Risk Assessment Map Book map reference)	Watercourse classification[3]	WFD water body and current overall status	WFD status objective (by 2027 as in RBMP)	Receptor value[4]	Q95[5] (m^3/s)	Catchment area at crossing (km^2)	Notes
Harefield No.2 Lake	Between the Alders and the GUC. There will be a 390m long crossing of the route between the Alders and the GUC. (SWC-CFA7-05 and CFA07-P04)	Ordinary watercourse	No status class in RBMP – assumed status. Poor	No status class in RBMP – assumed status. Good potential	Moderate	Not applicable	Not applicable	The lake is used for recreation by Hillingdon Outdoor Activity Centre. The lake does not appear to be directly connected to the GUC. The lake discharges into a watercourse which flows southwards and eventually joins Fray's River.
GUC	Eastern flank of Colne Valley - runs north-south through the area. (SWC-CFA7-01)	Artificial	GUC, Maple Lodge to Uxbridge. GB70610252 Moderate	Good potential (by 2015)	Very high	Not applicable	Not applicable	In the study area the GUC runs between Harefield No.2 Lake to the east and Savay Lake to the west. The canal continues southward before heading east near Yiewsley.
Unnamed lake	Unnamed lake (will be 270m north of the route and west of Harefield Moor). (CFA07-P02)	Not applicable	Not applicable	Not applicable	Moderate	Not applicable	Not applicable	Unnamed lake (former gravel pit). The western side of this lake is up to 100m from the eastern side of the lake/marina (CFA07-P03) described below and appears to be hydraulically isolated from it and any other surface water features in this area.
Lake/marina	Will be north of the route near South Harefield, adjacent to the GUC. (CFA07-P03).	Ordinary watercourse	No status class in RBMP – assumed status. Moderate	No status class in RBMP – assumed status. Good potential (by 2015)	High	Not applicable	Not applicable	The lake is well connected to the main channel of the GUC (Maple Lodge to Uxbridge) and has a marina, narrow boat slipway and jetties on the eastern side.

Water feature	Location description (Volume 5, Water Resources and Flood Risk Assessment Map Book map reference)	Watercourse classification[3]	WFD water body and current overall status	WFD status objective (by 2027 as in RBMP)	Receptor value[4]	Q95[5] (m^3/s)	Catchment area at crossing (km^2)	Notes
Three unnamed drains	Will be approximately 700m south of the route, within the Buckinghamshire Golf Course, east of Denham. (CFA07-P05)	Ordinary watercourse	No status class in RBMP – assumed status. Poor	No status class in RBMP – assumed status. Good potential	Moderate	Not applicable	Not applicable	The drains are potentially linked to the River Colne, which lies to the north of the golf course.
Two unnamed ponds	Will be approximately 700m south of the route, within the Buckinghamshire Golf Course, east of Denham. (CFA07-P05)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	These ponds do not appear to be in connectivity with other surface water features in this area and are likely to be man-made features as part of the golf course.
Savay Lake	Between the GUC and the River Colne, bounded to the north by Moorhall Road. (SWC-CFA7-06, SWC-CFA7 -08 and CFA07-P06)	Not applicable	Not applicable	Not applicable	High	Not applicable	Not applicable	The route will cross two different parts of Savay lake (approximately 300m). Savay Lake is used for fishing. The lake is not connected to other surface water features in the area.
Unnamed pond	Adjacent to Savay Lake, south of Moorhall Road. Will be crossed by the route. (SWC-CFA7-07 and CFA07-P07)	Not applicable	Not applicable	Not applicable	Moderate	Not applicable	Not applicable	This pond does not appear to be directly linked to Savay Lake but is situated only 10m away. The pond is not connected to other surface water features in the area.

Water feature	Location description (Volume 5, Water Resources and Flood Risk Assessment Map Book map reference)	Watercourse classification[3]	WFD water body and current overall status	WFD status objective (by 2027 as in RBMP)	Receptor value[4]	Q95[5] (m^3/s)	Catchment area at crossing (km^2)	Notes
Korda Lake	Part of Mid Colne Valley SSSI. Between Moorhill Road and the River Colne. (SWC-CFA7-09 and CFA07-P08)	Not applicable	Not applicable	Not applicable	Very high	Not applicable	Not applicable	The route will cross approximately 325m of Korda Lake. The lake is a flooded sand and gravel pit, used for recreation. The lake does not appear to be connected to other surface water features in the area.
Harefield Moor Lake	Part of Mid Colne Valley SSSI. The route will include a 55m long crossing between Moorhall Road and the River Colne, to the north of Korda Lake. (SWC-CFA7-10 and CFA07-P09)	Not applicable	Not applicable	Not applicable	Very high	Not applicable	Not applicable	The route will cross approximately 55m of this lake which is a flooded sand and gravel pit, used for recreation. The lake does not appear to be connected to other surface water features in the area.
Long Pond	Part of Mid Colne Valley SSSI. Between Harefield Moor Lake and the River Colne. (SWC-CFA7-11 and CFA07-P10)	Not applicable	Not applicable	Not applicable	Very high	Not applicable	Not applicable	The route will cross approximately 190m of Long Pond. The lake is a flooded sand and gravel pit. The lake does not appear to be connected to other surface water features in the area.
River Colne	Generally on western side of the valley bottom. The route will cross the river north of Denham Laboratories. (SWC-CFA7-03)	Main river	River Colne and GUC (from confluence with Chess to Ash). GB106039023090 Poor	Good potential	Very high	1.76	723.2	Runs between Long Pond of the Mid Colne Valley SSSI and the A412. The River Colne is a medium watercourse, which has been heavily modified in the region. It flows in a general north to south direction, parallel with the GUC, before joining the River Thames near Staines.

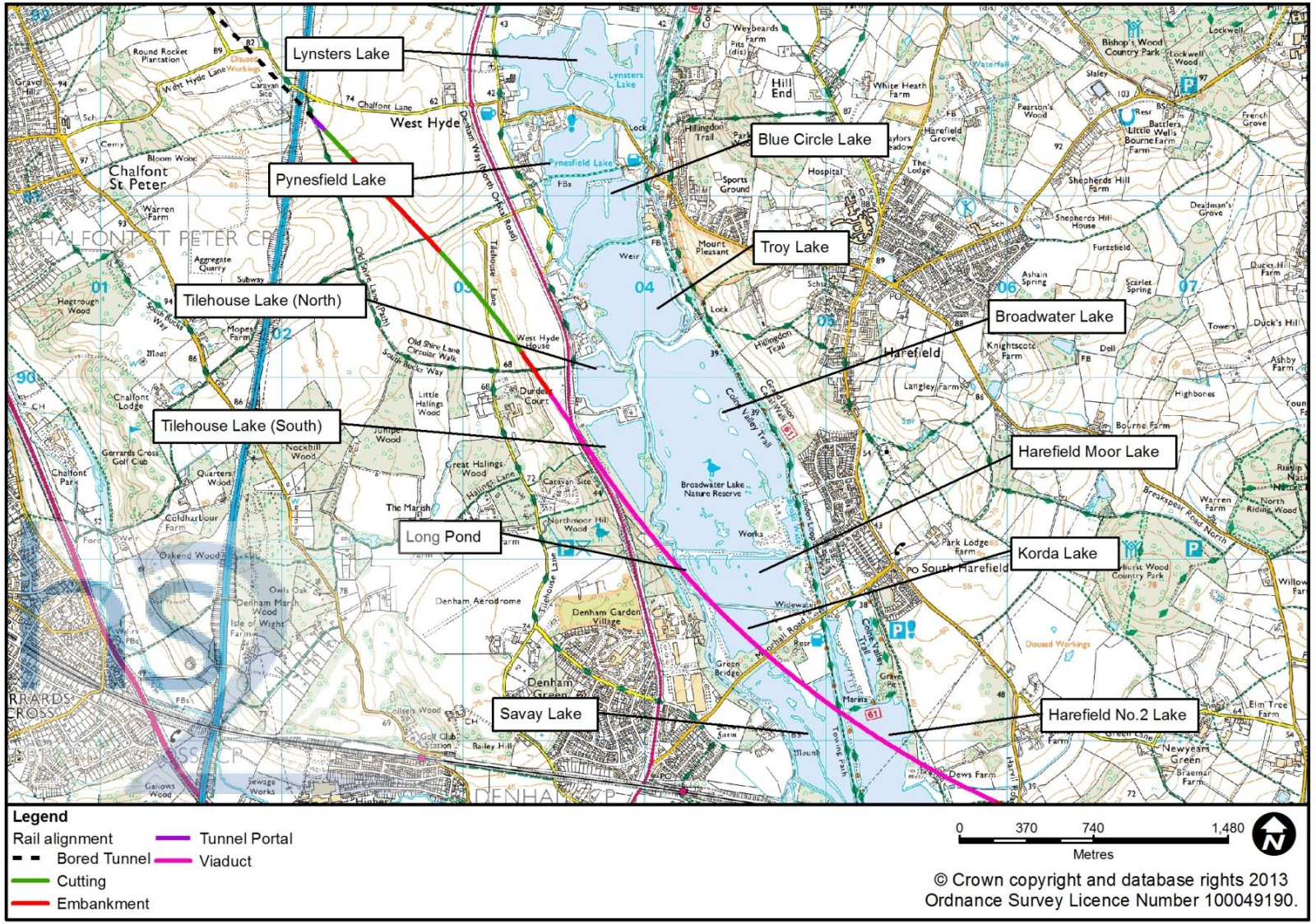
Water feature	Location description (Volume 5, Water Resources and Flood Risk Assessment Map Book map reference)	Watercourse classification[3]	WFD water body and current overall status	WFD status objective (by 2027 as in RBMP)	Receptor value[4]	Q95[5] (m^3/s)	Catchment area at crossing (km^2)	Notes
Unnamed lake	Unnamed lake will be approximately 50m south of the route, which is part of the Mid Colne Valley SSSI, west of Long Pond. (CFA07-P11)	Not applicable	Not applicable	Not applicable	Very High	Not applicable	Not applicable	The lake does not appear to be connected to other surface water features in the area.
Broadwater Lake Nature Reserve	The lake is part of the Mid Colne Valley SSSI. Will be 50m north of the route and east of the River Colne. (CFA07-P12)	Not applicable	Mid Colne Valley lake GB30641907 Good	Good Potential (by 2015)	Very High	Not applicable	Not applicable	Broadwater Lake is a nature reserve and has a WFD classification.
Two unnamed ponds	420m and 690m west of the route, located south of Great Hailings Wood near Denham Manor. (CFA07-P13)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	The ponds appear to be garden/landscaping features and are not connected to any other surface water features.
Tilehouse Lake (South)	This is a part of the Mid Colne Valley SSSI. Between the A412 and Broadwater Lake. (CFA07-P14)	Not applicable	Not applicable	Not applicable	High	Not applicable	Not applicable	The lake is not connected to other surface water features in the area.
Tilehouse Lake (North)	Between the A412 and Broadwater Lake and the River Colne. (CFA07-P15)	Not applicable	Not applicable	Not applicable	High	Not applicable	Not applicable	Not a part of the Mid Colne Valley SSSI. The lake is not connected to other surface water features in the area.

Water feature	Location description (Volume 5, Water Resources and Flood Risk Assessment Map Book map reference)	Watercourse classification[3]	WFD water body and current overall status	WFD status objective (by 2027 as in RBMP)	Receptor value[4]	Q95[5] (m^3/s)	Catchment area at crossing (km^2)	Notes
Troy Lake	Will be north (upstream) of the route. The lake lies west of South Harefield, directly north of Broadwater Lake and south of Blue Circle Lake. (CFA07-P16).	Not applicable	Not applicable	Not applicable	High	Not applicable	Not applicable	The lake has jetties on the eastern side. It is not a part of the Mid Colne Valley SSSI. The lake does not appear to be connected to other surface water features in the area.
Unnamed pond	Between the A412 and Troy Lake.	Not applicable	Not applicable	Not applicable	High	Not applicable	Not applicable	Small pond that is not a part of the Mid Colne Valley SSSI.
Unnamed braided watercourse, drains and ponds	Will be 350m north-east (upstream) of the route, near West Hyde House. (CFA07-P17).	Ordinary watercourse	No status class in RBMP – assumed status. Poor	No status class in RBMP – assumed status. Good potential	High	Not applicable	Not applicable	Braided channel connected to other drains and the River Colne, controlled by a series of weirs. There are approximately three ponds in the vicinity.
Tributary of River Colne (The Marish)	Chalk stream near Denham Park Farm which disappears at a sink. (SWC-CFA7-04)	Ordinary watercourse	No status class in RBMP – assumed status. Poor	No status class in RBMP – assumed status. Good potential	High	0.001	0.5	The tributary runs openly near Great Hailings Wood, approximately 615m west of the route, but then disappears at a sink and is presumed to join the River Colne to the east of the route in the vicinity of Weybeards Cottages.
Blue Circle Lake	Will be 510m north (upstream) of the route and west of South Harefield, north of Troy Lake and south of Pynesfield Lake. (CFA07-P18)	Not applicable	Not applicable	Not applicable	High	Not applicable	Not applicable	Not a part of the Mid Colne Valley SSSI. The lake does not appear to be directly connected to other surface water features in the area. It is over 500m upstream of the route.

Water feature	Location description (Volume 5, Water Resources and Flood Risk Assessment Map Book map reference)	Watercourse classification[3]	WFD water body and current overall status	WFD status objective (by 2027 as in RBMP)	Receptor value[4]	Q95[5] (m^3/s)	Catchment area at crossing (km^2)	Notes
Pynesfield Lake	Will be approximately 600m east (upstream) of the route. Currently situated between the GUC/River Colne to the east and West Hyde to the west. (CFA07-P19)	Not applicable	No status class in RBMP – assumed status. Poor	No status class in RBMP – assumed status. Good potential	High	Not applicable	Not applicable	A footpath causeway crosses this lake. The two sides are hydraulically connected. This lake may have some connectivity with one of the drains that run north to south to the west of Pynesfield Lake and eventually into the River Colne.
Five unnamed ponds	Will be approximately 690m north (upstream) of the route, near West Hyde and Pynesfield Lake. (CFA07-P20)	Not applicable	Not applicable	Not applicable	Moderate	Not applicable	Not applicable	A group of small ponds that are hydraulically connected.
Two unnamed drains	Will be approximately 690m north (upstream) of the route, near West Hyde and Pynesfield Lake. (CFA07-P20)	Ordinary watercourses	No status class in RBMP – assumed status. Poor	No status class in RBMP – assumed status. Good potential	High	Not applicable	Not applicable	The drains may be in connectivity with the River Colne to the south of Pynesfield Lake.
Lynsters Lake	Will be approximately 900m east (upstream) of the route, between the GUC/River Colne to the east and West Hyde to the west. (CFA07-P21)	Not applicable	No status class in RBMP – assumed status. Poor	No status class in RBMP – assumed status. Good potential	High	Not applicable	Not applicable	A group of three lakes, some of which are hydraulically connected. Not a part of the Mid Colne Valley SSSI. There could be hydraulic connectivity between two of the Lynsters Lakes and Pynesfield Lake, which in turn is connected to the River Colne.

Water feature	Location description (Volume 5, Water Resources and Flood Risk Assessment Map Book map reference)	Watercourse classification[3]	WFD water body and current overall status	WFD status objective (by 2027 as in RBMP)	Receptor value[4]	Q95[5] (m^3/s)	Catchment area at crossing (km^2)	Notes
Unnamed field pond	Will be approximately 830m south of the route, to the north of Nockhill Wood. (CFA07-P22)	Not applicable	Not applicable	Not applicable	Low	Not applicable	Not applicable	Isolated field pond; not connected to any other surface water feature.
Unnamed balancing pond	Will be approximately 200m south of the route, near the M25. (CFA07-P23)	Not applicable	Not applicable	Not applicable	Moderate	Not applicable	Not applicable	Labelled as a balancing pond on OS mapping. It is an artificial water body that receives drainage from the M25 motorway.

Figure 1: Map of Colne Valley lakes



3.2.6 There are no surface water abstractions identified within 1km of the route. There is the potential for further unlicensed abstractions to exist, as a licence is not required for abstraction volumes below 20m³ per day.

3.2.7 Table 2 summarises surface water discharge consents within 1km of the route. There is a major discharge into the River Colne from Maple Cross sewage treatment works and although it is more than 1km upstream of the route it is expected to affect baseline water quality of the river in the study area.

Table 2: Surface water discharge consents

Reference number	Permit identifier	Distance (and direction) from route (m)	Discharge type	Receiving water body
CFA7WD3	CNTM.0832	610m (west)	Sewage discharge – pumping station	Newyears Green Bourne
CFA7WD5	CNTM.1219	280m (west)	Trade effluent discharge – site drainage	Tiles ditch
CFA7WD15	CTCR.2040	95m (west)	Trade discharge – process water	River Colne
CFA7WD17	CATM.3624	35m (east)	Sewage discharge – final/treated effluent	River Colne
CFA7WD19	CTWC.0180	610m (east)	Sewage discharge – final/treated effluent	Harefield Moor Lake
CFA7WD26	CATM.2403	970m (east)	Sewage discharge – final/treated effluent	River Colne
CFA7WD28	CATM.3643	380m (east)	Sewage discharge – final/treated effluent	Tributary of River Colne
CFA7WD88	CANM.0821	845m (east)	Trade effluent discharge – site drainage	River Colne
CFA7WD92	CANM.1095	340m (east)	Sewage and trade combined – unspecified	GUC
CFA7WD95	NPSWQD001433	340m (east)	Sewage discharge – final/treated effluent	River Colne (Troy Arm loop)
CFA7WD100	TEMP.0462	945m (east)	Sewage discharge – pumping station	GUC
CFA7WD101	TEMP.0833	75m (west)	Sewage discharge – pumping station	Newyears Green Bourne
CFA7WD103	TEMP.2205	770m (east)	Sewage discharge – pumping station	River Colne

3.3 Groundwater

3.3.1 A summary of the geological units present in CFA7, along with their hydrogeological characteristics, is presented in the Land Quality section in Volume 2, CFA Report 7, Section 8.

3.3.2 Map WR-02-007 (Volume 5, Water Resources and Flood Risk Assessment Map Book) indicates the spatial distribution of the uppermost superficial and bedrock formations within CFA7. A schematic cross-section along the line of the route in this area showing the geological strata, any known groundwater elevations and the vertical location of the route is presented in Figure 2.

3.3.3 Figure 3 presents the 1976 drought condition groundwater level contours for this study area and adjacent areas, using data from the Hydrogeological Map[6] (Institute of Geological Sciences, 1978) which was considered to follow a period of drought and low groundwater elevations. The contours indicate that the regional direction of groundwater flow is to the south-east with a gradient of approximately 0.45% (10 metres fall in groundwater level about every 2.2km). The contours show that Chalk groundwater levels close to the Colne Valley were 30 metres above Ordnance Datum (m AOD) near Harefield No. 2 Lake rising to 40m AOD near Tilehouse Lane.

3.3.4 The Environment Agency observation borehole monitoring data indicates that maximum recorded groundwater levels in winter 2001/2 (which is considered to represent a period of extremely high groundwater elevations) were 37m AOD near Denham Garden village, rising to 41m AOD at Tilehouse Lane and 67m AOD at the Chalfont Centre in the adjacent study area. This suggests peak groundwater levels will generally be below the base of the route along the entire route within this study area, with the exception of the foundations for the Colne Valley viaduct, which will extend below the water table.

3.3.5 There are three groundwater abstractions for PWS protected by SPZ in the study area (the SPZ numbers are TH177, TH027 and TH171) as listed in Table 3. There is one further source (protected by SPZ TH174) which is located in the adjacent study area, the South Ruislip to Ickenham community forum area (CFA6), but its SPZ extends into CFA7.

3.3.6 All four PWS are located to the north of the route at distances ranging from less than 50m to almost 1km. The shape of the SPZ mirrors the regional groundwater level contour map and confirms that groundwater flow will be to the south-east. The groundwater level contours and shape of the SPZ indicate that some of the groundwater entering the PWS will be drawn from areas hydraulically down gradient of the route.

3.3.7 Groundwater flow in the Chalk is usually dominated by flow in fissures. The depths of major fissures bands under the floor of the valley include a zone around 20-30m below

[6] Institute of Geological Sciences (1978). South-west Chilterns hydrogeological map. 1:100,000 map, British Geological Survey, ISBN No :0751811823.

ground level (BGL) and another zone around 45m BGL (Shand, P. et al., (2003)[7] and Environment Agency (2005)[8]).

3.3.8 There are a number of private abstractions from groundwater (licensed and unlicensed) in the study area. These have nominal protected areas set around them by the Environment Agency some of which will be crossed by the route. The sources are listed and described in Table 3.

3.3.9 According to the LBH report[9], there is an area of groundwater contamination in the Chalk aquifer associated with a closed landfill north of the route near Ickenham. A contaminated groundwater plume that has elevated concentrations of ammonium is present to the north of the Proposed Scheme. The data available from the local authority indicate that groundwater levels in the Chalk aquifer are around 10m below the route in this study area.

3.3.10 There is another area of historic groundwater contamination in the area of Denham Studios where a pump and treat scheme is in operation.

[7] Shand, P., Tyler-Whittle R., Bersien T., Peach D.W., Lawrence A.R. and Lewis H.O., 2003. BGS Baseline Report Series: 6. The Chalk of the Colne and Lee River Catchments. Environment Agency Technical Report NC/99/74/6 and BGS commissioned report CR/03/69N.
[8] Environment Agency (2005). Groundwater quality review: The Chalk of the Mid-Chilterns and Colne Valley, Thames Region. Report Reference: 6441R4.
[9] London Borough of Hillingdon (2011). Environmental Protection Act 1990, Part 2A – Section 78B,Record of Determination of the Land at the Former Landfill Site at New Years Green Lane, Harefield, Middlesex

Figure 2: Schematic geological cross-section for CFA7.

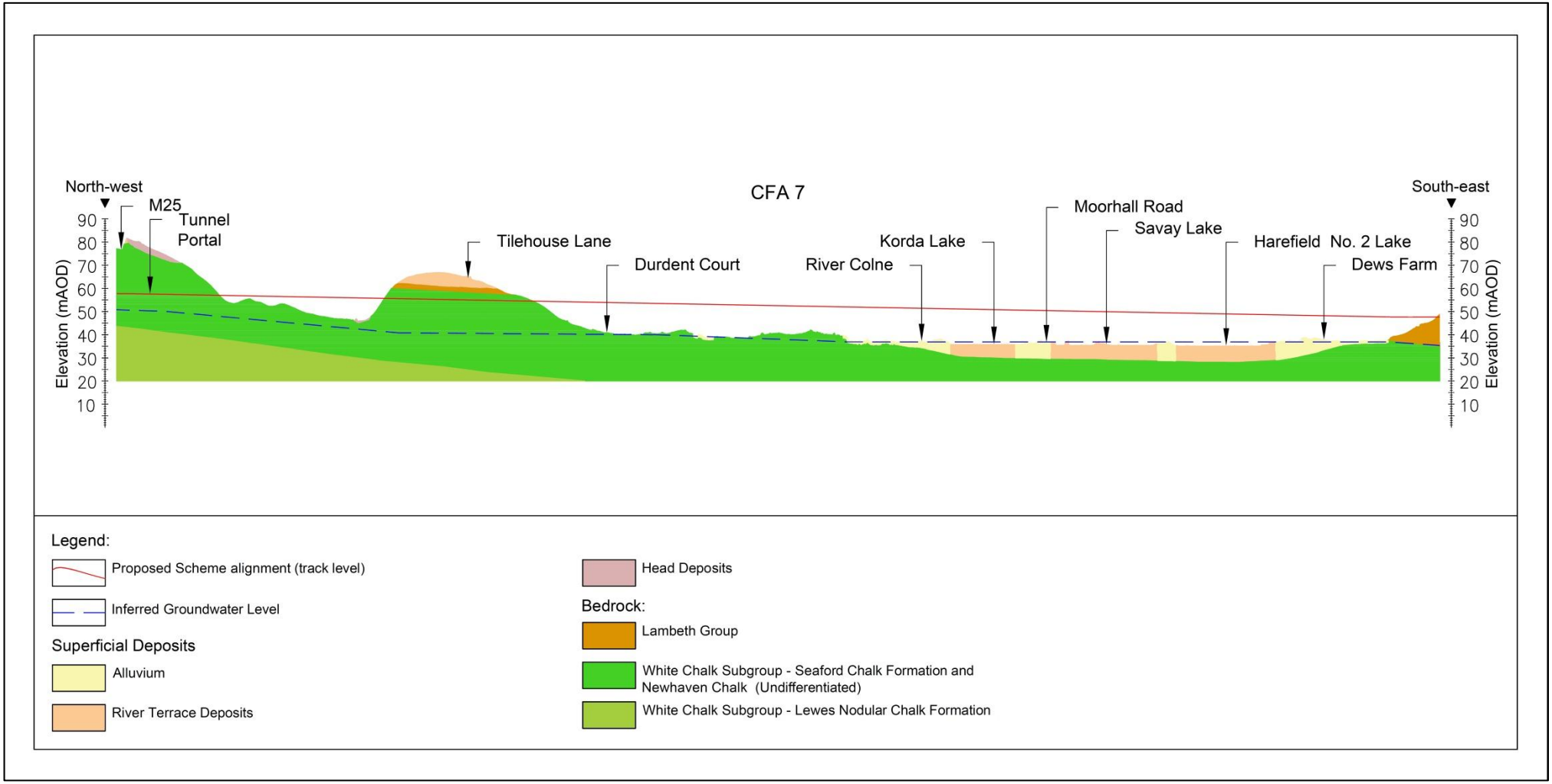
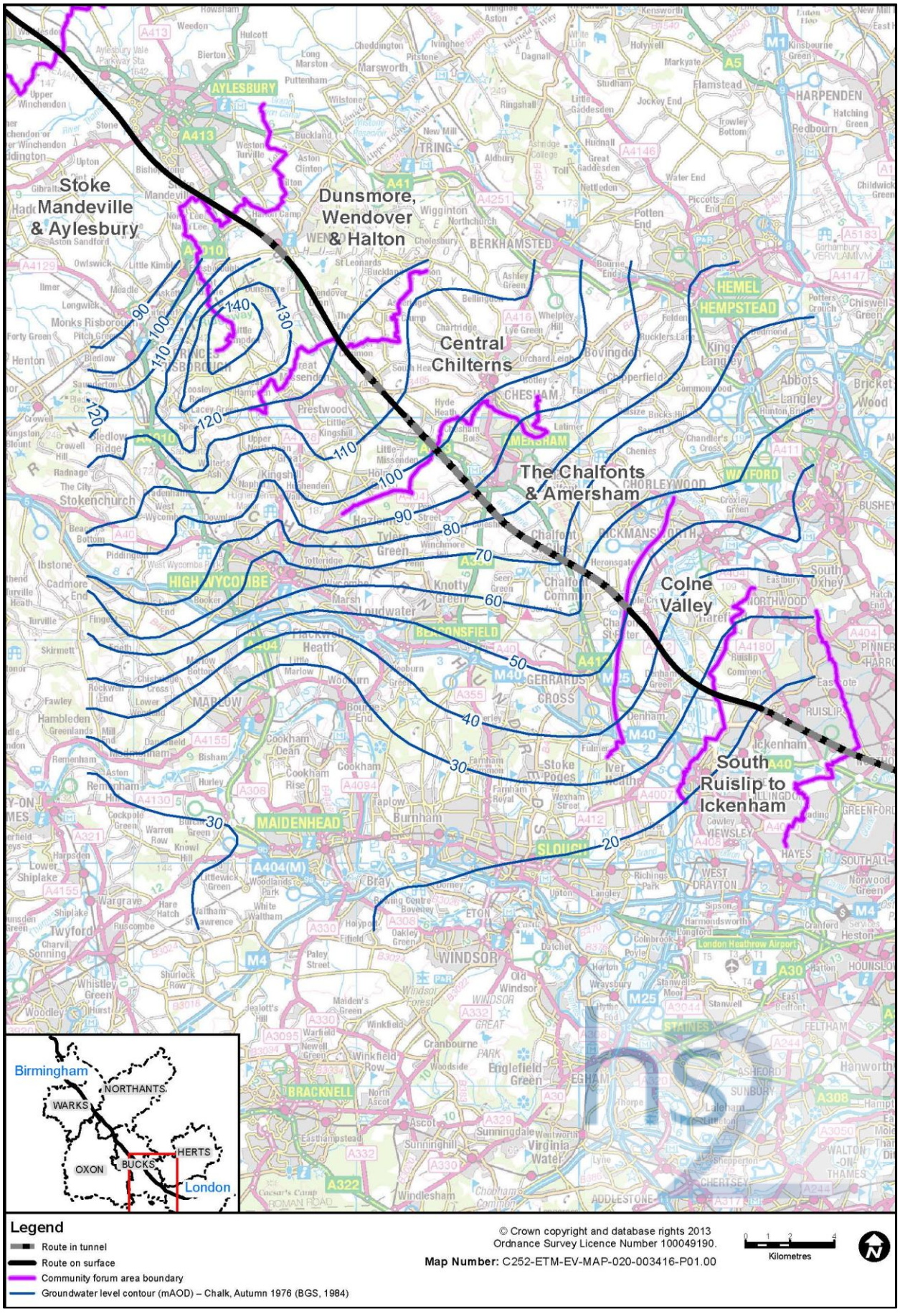


Figure 3: Groundwater elevation contours for this study area and the surrounding area



3.3.11 Table 3 summarises unlicensed and licensed private groundwater abstractions and SPZ associated with PWS within 1km of the route. There is the potential for further unlicensed abstractions to exist, as a licence is not required for abstraction volumes below 20m³ per day.

Table 3: Summary of groundwater abstractions

Licence identifier (map reference number and Environment Agency reference)	**Distance and direction from route (m)**	**Abstraction horizon**	**Maximum annual abstraction quantity (m^3)**	**Maximum daily abstraction quantity (m^3/d)**	**Purpose**	**Number of boreholes**
Public water supplies						
TH177 (licence identifier confidential)	SPZ will be crossed by route, SPZ largely to the north of the route	Chalk	32,120,000 (Seven abstractions within group licence)	20,000	PWS	3
TH027 (licence identifier confidential)	330m (north-east)	Chalk	As above	18,184	PWS	3
TH171 (licence identifier confidential)	950m (north-east)	Chalk	As above	20,457	PWS	2
TH174 - source located in CFA6 (licence identifier confidential)	280m (north)	Chalk	As above	12,502	PWS	3
Private licensed water supplies						
GW37 (28/39/28/0491)	725m (south-west)	Unknown	1,095,000	3,000	Golf course, top-up water	Two within licence (includes GW38)
GW25 (28/39/28/0101)	220m (north-east)	Chalk	580,752	1,591	Laboratory, process water	Two within licence (includes GW26)
GW27 (28/39/28/0448)	200m (north-east)	Chalk	580,763	1,591	Laboratory, process water	Two within licence (includes GW28)

GW28 (28/39/28/0448)	140m (north-east)	Chalk	147,749	404	Groundwater remediation borehole	Two within licence (includes GW27)
GW42 (28/39/28/0509)	585m (south-west)	Chalk	272,760	1,092	Quarry, mineral washing	1
GW36 (28/39/28/0037)	385m (north-east)	River Gravels	166,420	582	Quarry, mineral washing	1
GW32 (28/39/28/0052)	455m (north-east)	River Gravels	409,140	1,364	Quarry, mineral washing	1
GW33 (28/39/28/0052)	530m (north-east)	River Gravels	53,188	177	Quarry, process water	1
GW24 (28/39/28/0584)	930m (north-east)	River Gravels	13,505	37	Groundwater remediation borehole	1
GW17C (28/39/28/0358)	25m (north-east)	Chalk	7,274	291	General farming and domestic	1
Private unlicensed water supplies						
UGA171 (CFA07-GWUA01)	820m (north-east)	Chalk	Unknown	<20	Public, sailing club	1

3.3.12 Table 4 summarises groundwater discharge consents to groundwater, directly or via land, within 1km of the route.

Table 4: Discharge consents to groundwater

Reference number	Permit identifier	Distance and direction from route (m)	Discharge type	Receiving water body
CFA7WD1	CTWC.3058	395m (north-east)	Sewage discharges - final/treated effluent - not water company	Alluvium and Made Ground
CFA7WD8	CTWC.3597	865m (south-west)	Sewage discharges - final/treated effluent - not water company	Glacial Gravels
CFA7WD11	CTCU.1348	565m (south-west)	Sewage discharges - final/treated effluent - not water company	Glacial Gravels
CFA7WD14	CTCU.0609	235m (south-west)	Trade discharge – process water	Chalk

3.4 Surface water/groundwater interaction

3.4.1 Table 5 summarises the surface water/groundwater interactions within 1km of the route. Refer to Map WR-01-008 (Volume 5, Water Resources and Flood Risk Assessment Map Book) for location of lakes and other surface water features.

Table 5 : Surface water/groundwater interaction

Location description (and map reference)	Distance (m) and direction from route	Formation	Elevation (m AOD)	Comments
Savay Lake (SWC-CFA7-06, SWC-CFA7-08 and CFA07-P06)	Crossed by route	Shepperton Gravel Member	40m AOD	Groundwater level and lake level data indicate that there is a degree of hydraulic connectivity between the lakes, superficial gravels and Chalk groundwater. Further discussion regarding the surface water connectivity of these lakes is given in Table 1.
Harefield No. 2 Lake (SWC-CFA7-05 and CFA07-P04)	Crossed by route			
Korda Lake (SWC-CFA7-09 and CFA07-P08)	Crossed by route			
Long Pond (SWC-CFA7-11)	Crossed by route			
Harefield Moor Lake (SWC-CFA7-10 and CFA07-P09)	Crossed by route			
Broadwater Lake (CFA07-P12)	35m (north-east)			
Tilehouse Lake (South) (CFA07-P14)	35m (north-east)			
Tilehouse Lake (North) (CFA07-P15)	120m (north-east)			
Troy Lake (CFA07-P16).	420m (north-east)			
Blue Circle Lake (CFA07-P18)	500m (north-east)			
Pynesfield Lake (CFA07-P19)	560m (north-east)			
Lynsters Lake (CFA07-P21)	805m (north-east)			

Location description (and map reference)	Distance (m) and direction from route	Formation	Elevation (m AOD)	Comments
River Colne (SWC-CFA7-03)	Crossed by route	Alluvium, over Shepperton Gravel Member	40m AOD	Groundwater level and river level data indicate a degree of hydraulic connectivity with the River Colne within 1km of the route.

3.5 Water dependent habitats

3.5.1 Table 6 summarises the water dependent habitats within 1km of the route. The table identifies where a water dependency exists. The assessment of residual impact or mitigation measures on water dependent ecology receptors is found in the Ecology section in Volume 2, CFA Report 7, Section 7. Map references are given for the Volume 5, Ecology Map Book.

Table 6: Description of water dependent habitats

Name/location[10]	Distance from route	Designation	Comments
The River Colne, flooded pits and GUC (Map EC-01-011 and EC-01-012)	Crossed by route	Marginal vegetation	These water dependant habitats occupy parts of the valley floor and are expected to show a degree of hydraulic continuity with the gravel aquifers that remain after quarrying. The superficial deposits may also have a connection to the fractures found at depth in the Chalk aquifer.
Mid Colne Valley SSSI (Maps EC-01-011 and EC-01-012)	Crossed by route	SSSI	The route will cross the Mid Colne Valley SSSI. This SSSI consists of five large lakes between the River Colne and GUC. It is a 'very high' value receptor due to its national SSSI status, the water related aspects of which includes the River Colne, local wetlands and associated bird life. The lakes are also expected to show some hydraulic connectivity with groundwater as described above

[10] Map references to Volume 5: Ecology Map Book

4 Site specific surface water assessment

4.1 Summary of assessment

4.1.1 Table 7 summarises the potential impacts and effects to surface water features from the Proposed Scheme in the study area. Only those impacts and effects that are classed as significant are presented in Volume 2, CFA Report 7, Section 13.4.

4.1.2 Table 7 only includes water features which could potentially be impacted by the Proposed Scheme. Features such as isolated ponds and drains which will lie outside the construction footprint and area of impact of the Proposed Scheme are not included. Details of these features are, however, provided in Table 1. Map references refer to those presented on Map WR-01-008 (Volume 5, Water Resources and Flood Risk Assessment Map Book).

4.1.3 The draft CoCP referred to in Table 7 sets out the measures and standards of work that will be applied to the construction of the Proposed Scheme (see Volume 5: Appendix CT-003-000/1). These will provide effective management and control of the impacts during the construction period.

Table 7: Summary of potential impacts to surface water

Surface water feature/ receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Water features									
Four unnamed field drains near Shorthill Cottage	Low	Viaduct UK Power Networks Construction (Electrical high voltage power supply)	The field drains are not linked to watercourses in the catchment. The most northern drain is close to construction of electrical lines (above ground).	Negligible impact Neutral effect (Not significant)	None required	Negligible impact Neutral effect (Not significant)	None required	None	Not applicable
Newyears Green Bourne located near Dews Farm (SWC-CFA7-02)	High	Viaduct	Potential sediment mobilisation or spills during construction See Section 4.2 of this report for further details.	Moderate impact Moderate – large effect (Significant)	Monitoring during construction Draft CoCP measures to control sediment mobilisation and risk of spills.	Negligible impact Neutral effect (Not significant)	None required	Negligible impact Neutral effect (Not significant)	Construction (temporary)
Three unnamed lakes (Fray's Valley Local Nature Reserve)	High	Viaduct UK Power Networks Construction (Electrical high voltage power supply)	The lakes are 370m to 1km south of the route. There are also four smaller pond bodies near the lakes and small field drains. No impacts likely to occur.	Negligible impact Neutral effect (Not significant)	None required	Negligible impact Neutral effect (Not significant)	None required	None	Not applicable
Unnamed lake (north of the route near South Harefield)	Moderate	Viaduct	The lake is hydraulically isolated from the scheme. No impact likely to occur.	Negligible impact Neutral effect (Not significant)	None required	Negligible impact Neutral effect (Not significant)	None required	None	Not applicable

Surface water feature/ receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Lake/marina (north of the route near South Harefield)	High	Viaduct	Construction on land close to the lake shore may impact on water quality	Minor impact Slight effect (Not significant)	Implementing the draft CoCP will protect surface water quality	Negligible impact Neutral effect (Not significant)	None required	Negligible impact Neutral effect (Not significant)	Construction (temporary)
Harefield No.2 Lake (situated between the Alders and the GUC) (SWC-CFA7-05 and CFA7-P04)	High	Viaduct (pier construction, footings)	The route will cross approximately 390m of the lake. Approximately 10 pier footings will be constructed in the lake and construction areas are identified on the northern edges of the lake. See Section 4.2 of this report for further details.	Moderate impact Large effect (Significant)	Monitoring during construction Draft CoCP measures to control sediment mobilisation and risk of spills.	Negligible impact Neutral effect (Not significant)	None required	Negligible impact Neutral effect (Not significant)	Construction (temporary)
Harefield No.2 Lake (situated between the Alders and the GUC) (SWC-CFA7-05 and CFA7-P04)	High	Viaduct (runoff and spills)	Runoff and spills from the viaduct may impact on water quality. See Section 4.2 of this report for further details.	Negligible impact Neutral effect (Not significant)	See Section 4.2 of this report for further details.	Negligible impact Neutral effect (Not significant)	None required	Negligible impact Neutral effect (Not significant)	Construction (permanent)

Surface water feature/ receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
GUC (SWC-CFA7-01)	Very high	Viaduct	Construction of piers and footings next to the canal may affect water quality. See Section 4.2 of this report for further details.	Negligible impact Neutral effect (Not significant)	Monitoring during construction CoCP measures to control sediment mobilisation and risk of spills.	Negligible impact Neutral effect (Not significant)	None required	None	Construction (temporary)
Three unnamed drains and two ponds within the golf course	Moderate	Viaduct	The construction and operation of the Proposed Scheme is likely to not impact the drains.	Negligible impact Neutral effect (Not significant)	None required	Negligible impact Neutral effect (Not significant)	None required	None	Not applicable
Savay Lake and unnamed pond (SWC-CFA7-06, 07 and 08)	High	Viaduct (pier construction, footings)	The route will cross two different parts of Savay lake and an unnamed pond (approximately 300m) Approximately nine pier footings will be constructed across the lake See Section 4.2 of this report for further details.	Moderate impact Large effect (Significant)	Monitoring during construction Draft CoCP measures to control sediment mobilisation and risk of spills.	Negligible impact Neutral effect (Not significant)	None required	Negligible impact Neutral effect (Not significant)	Construction (temporary)
Savay Lake and unnamed pond (SWC-CFA7-06, 07 and 08)	High	Viaduct (runoff and spills)	Runoff and spills from the viaduct may impact on water quality. See Section 4.2 of this report for further details.	Negligible impact Neutral effect (Not significant)	See Section 4.2 of this report for further details.	Negligible impact Neutral effect (Not significant)	None required	Negligible impact Neutral effect (Not significant)	Construction (permanent)

Surface water feature/ receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Korda Lake (SWC-CFA7-09)	Very high	Viaduct (pier construction, footings)	The route will cross approximately 325m of the lake. The lake is part of the Mid Colne Valley SSSI. Approximately eight pier footings will be constructed in the lake. See Section 4.2 of this report for further details.	Moderate impact Large/very large effect (Significant)	Monitoring during construction CoCP measures to control sediment mobilisation and risk of spills.	Negligible impact Neutral effect (Not significant)	None required	Negligible impact Neutral effect (Not significant)	Construction (temporary)
Korda Lake (SWC-CFA7-09)	Very high	Viaduct (runoff and spills)	Runoff and spills from the viaduct may impact on water quality. The lake is part of the Mid Colne Valley SSSI. See Section 4.2 of this report for further details.	Negligible impact Neutral effect (Not significant)	See Section 4.2 of this report for further details.	Negligible impact Neutral effect (Not significant)	None required	Negligible impact Neutral effect (Not significant)	Construction (permanent)
Harefield Moor Lake (SWC-CFA7-10)	Very high	Viaduct (pier construction, footings)	The route will cross approximately 55m of the lake. The lake is part of the Mid Colne Valley SSSI. Approximately 2 pier footings will be constructed across the lake. See Section 4.2 of this report for further details.	Moderate impact Large/very large effect (Significant)	Monitoring during construction Draft CoCP measures to control sediment mobilisation and risk of spills.	Negligible impact Neutral effect (Not significant)	None required	Negligible impact Neutral effect (Not significant)	Construction (temporary)

Surface water feature/ receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Harefield Moor Lake (SWC-CFA7-10)	Very high	Viaduct (runoff and spills)	Runoff and spills from the viaduct may impact on water quality. The lake is part of the Mid Colne Valley SSSI. See Section 4.2 of this report for further details.	Negligible impact Neutral effect (Not significant)	See Section 4.2 of this report for further details.	Negligible impact Neutral effect (Not significant)	None required	Negligible impact Neutral effect (Not significant)	Construction (permanent)
Long Pond (SWC-CFA7-11)	Very high	Viaduct (pier construction, footings)	The route will cross approximately 190m of the lake. The lake is part of the Mid Colne Valley SSSI. Approximately six pier footings will be constructed across the lake. See Section 4.2 of this report for further details.	Moderate impact Large/very large effect (Significant)	Monitoring during construction Draft CoCP measures to control sediment mobilisation and risk of spills.	Negligible impact Neutral effect (Not significant)	None required	Negligible impact Neutral effect (Not significant)	Construction (temporary)
Long Pond (SWC-CFA7-11)	Very high	Viaduct (runoff and spills)	Runoff and spills from the viaduct may impact on water quality. The lake is part of the Mid Colne Valley SSSI. See Section 4.2 of this report for further details.	Minor impact Moderate effect (Significant)	See Section 4.2 of this report for further details.	Negligible impact Neutral effect (Not significant)	None required	Negligible impact Neutral effect (Not significant)	Construction (permanent)

Surface water feature/ receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
River Colne (SWC-CFA7-03)	Very high	Viaduct	Potential sediment mobilisation or spills during construction See Section 4.2 of this report for further details.	Moderate – major impact Large/very large effect (Significant)	The diversion channel will be constructed in advance. Monitoring during construction CoCP measures to control sediment mobilisation and risk of spills.	Negligible impact Neutral effect (Not significant)	None	Negligible impact Neutral effect (Not significant)	Construction (temporary)
Unnamed lake south of the route between the River Colne and Battlesford Wood (CFA7-P11)	Very high	Viaduct	The lake is a part of the Mid Colne Valley SSSI. It is not likely that the construction and operation of the Proposed Scheme will impact the lake.	Negligible impact Neutral effect (Not significant)	None required Pre- and post-construction monitoring Draft CoCP measures will reduce the impact during construction to negligible.	Negligible impact Neutral effect (Not significant)	None required	None	Not applicable
Broadwater Lake Nature Reserve (CFA7-P12)	Very high	Viaduct	Broadwater Lake is a nature reserve and a part of the Mid Colne Valley SSSI. The construction and operation of the Proposed Scheme will likely not impact the lake.	Negligible impact Neutral effect (Not significant)	None required Draft CoCP measures will reduce the impact during construction to negligible.	Negligible impact Neutral effect (Not significant)	None required	None	Not applicable

Surface water feature/ receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Two unnamed ponds south of Great Hailings Wood (CFA7-P13)	Low	Viaduct	The construction and operation of the Proposed Scheme is not considered likely to impact these features.	Negligible impact Neutral effect (Not significant)	None required	Negligible impact Neutral effect (Not significant)	None required	None	Not applicable
Tilehouse Lake (south) (CFA7-P14)	Very High	Viaduct	The lake is a part of the Mid Colne Valley SSSI. The construction and operation of the Proposed Scheme will likely not impact the lake.	Negligible impact Neutral effect (Not significant)	None required. Draft CoCP measures will reduce the impact during construction to negligible.	Negligible impact Neutral effect (Not significant)	None required	None	Not applicable
Tilehouse Lake (north) (CFA7-P15)	High	Viaduct	Not a part of the Mid Colne Valley SSSI,. The construction and operation of the Proposed Scheme is not likely to impact the lake.	Negligible impact Neutral effect (Not significant)	None required Draft CoCP measures will reduce the impact during construction to negligible.	Negligible impact Neutral effect (Not significant)	None required	None	Not applicable
Troy Lake (CFA-P16)	High	Viaduct	The construction and operation of the Proposed Scheme is not likely to impact the lake.	Negligible impact Neutral effect (Not significant)	None required Draft CoCP measures will reduce the impact during construction to negligible.	Negligible impact Neutral effect (Not significant)	None required	None	Not applicable

Surface water feature/ receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Unnamed lake	High	Viaduct	The construction and operation of the Proposed Scheme is not likely to impact the lake.	Negligible impact Neutral effect (Not significant)	None required Draft CoCP measures will reduce the impact during construction to negligible.	Negligible impact Neutral effect (Not significant)	None required	None	Not applicable
Unnamed braided watercourse and ponds near West Hyde House (CFA7-P17)	High	Viaduct	Unnamed channel connected to other drains and the River Colne. There are approximately three ponds in the vicinity. The unnamed channel is controlled by a series of weirs.	Negligible impact Neutral effect (Not significant)	None required	Negligible impact Neutral effect (Not significant)	None required	None	Not applicable
Tributary of River Colne (The Marish) (SWC-CFA7-4)	High	Viaduct	It is not clear exactly where flow from this Chalk stream enters the River Colne. Construction works for the viaduct will have negligible impact on the existing situation.	Negligible impact Neutral effect (Not significant)	None required	Negligible impact Neutral effect (Not significant)	None required	None	Not applicable
Blue Circle Lake (CFA7-P18)	High	Viaduct	The construction and operation of the Proposed Scheme will likely not impact the lakes. Draft CoCP measures will reduce the impact during construction to negligible.	Negligible impact Neutral effect (Not significant)	None required	Negligible impact Neutral effect (Not significant)	None required	None	Not applicable

Surface water feature/ receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Pynesfield Lake (CFA7-P19)	High	Cuttings construction	The construction and operation of the Proposed Scheme will likely not impact the lakes. Draft CoCP measures will reduce the impact during construction to negligible.	Negligible impact Neutral effect (Not significant)	None required	Negligible impact Neutral effect (Not significant)	None required	None	Not applicable
Five unnamed ponds and two unnamed drains near West Hyde and Pynesfield Lake (CFA7-P20)	Moderate	Cuttings construction	The construction and operation of the Proposed Scheme is not likely to impact the lakes and drains. Draft CoCP measures will reduce the impact during construction to negligible.	Negligible impact Neutral effect (Not significant)	None required	Negligible impact Neutral effect (Not significant)	None required	None	Not applicable
Lynsters Lake (CFA7-P21)	High	Cuttings construction	The construction and operation of the Proposed Scheme is not likely to impact the lake. Draft CoCP measures will reduce the impact during construction to negligible.	Negligible impact Neutral effect (Not significant)	None required	Negligible impact Neutral effect (Not significant)	None required	None	Not applicable
Unnamed field pond to the north of Nockhill Wood (CFA7-P22)	Low	Cuttings construction	The pond is not connected to any other surface water feature. It is not likely that there will be an impact on this pond.	Negligible impact Neutral effect (Not significant)	None required	Negligible impact Neutral effect (Not significant)	None required	None	Not applicable

Surface water feature/ receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact and effect	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Unnamed M25 drainage balancing pond (CFA7-P23)	Moderate	Tunnel portal construction	The construction and operation of the Proposed Scheme is not likely to impact this M25 drainage pond. Draft CoCP measures will control and reduce the impact during construction to negligible.	Negligible impact Neutral effect (Not significant)	None required	Negligible impact Neutral effect (Not significant)	None required	None	Not applicable
Colne Valley Lakes or River Colne	High	Heavy goods vehicle (HGV) traffic - temporary M25 slip roads	Water quality deterioration from highway drainage See Section 4.2 of this report for further details.	Negligible impact Neutral effect (Not significant)	None required	Negligible impact Neutral effect (Not significant)	None required	None	Not applicable
Colne Valley Lakes	High	Increased HGV traffic on Harvil Road	Water quality deterioration from highway drainage See Section 4.2 of this report for further details.	Negligible impact Neutral effect (Not significant)	None required	Negligible impact Neutral effect (Not significant)	None required	None	Not applicable

4.2 Detailed assessments

Introduction

4.2.1 Much of the proposed route within CFA7 will be on a viaduct of approximately 3.3km in length spanning the Newyears Green Bourne, GUC, the River Colne and several lakes. The River Colne, GUC and some adjacent water bodies make up the Mid Colne Valley SSSI and are classified as very high value receptors. The detailed assessments in the following paragraphs cover:

- diverting or realigning channels;
- constructing piles and pile caps in, and the viaduct over, the surface water bodies; and
- drainage from the viaduct.

4.2.2 The locations and descriptions of the surface water crossings in the Colne Valley area are given in Table 8.

Table 8: Proposals for surface water crossings

Water feature	Crossing map reference (Map WR-01-008)	Description	Length[1] (m) and coverage of water body surface area (%)	WFD water body, designation and status
Newyears Green Bourne	SWC-CFA7-02	Two viaduct piers will have foundations that will impact the existing active channel. The watercourse will be permanently realigned between the piers.	140m	No status class in RBMP – assumed status Poor
GUC	SWC-CFA7-01	Viaduct piers will be on either bank of the existing active channel. No channel diversion required.	Not applicable	GUC, Maple Lodge to Uxbridge (GB70610252) Moderate
River Colne	SWC-CFA7-03	Two viaduct piers will be constructed within the existing active channel. The watercourse will be permanently diverted around the piers.	1,709m	Colne and GUC (from confluence with Chess to Ash) (GB106039023090) Poor
Harefield No.2 Lake	SWC-CFA7-05	Ten piers will be constructed within the water body.	390m 4% of the lake surface area.	Not applicable
Savay Lake	SWC-CFA7-06 SWC-CFA7-07 SWC-CFA7-08	Ten piers will be constructed within the water body across three different sections of the lake.	290m in total 2% of the lake surface area.	Not applicable
Korda Lake	SWC-CFA7-09	Eight piers will be constructed within the water body.	325m 8% of the lake surface area	Not applicable

Harefield Moor Lake	SWC-CFA7-10	Two piers will be constructed within the water body.	55m <1% of the lake surface area	Not applicable
Long Pond	SWC-CFA7-11	Six piers will be constructed within the water body.	190m 29% of the lake surface area	Not applicable

[1] The length is based on the consolidated construction boundary

Permanent channel diversion of the River Colne and Newyears Green Bourne

4.2.3 Since there are piers and associated pile caps (foundations) to be built within the existing active channels it will be necessary to permanently realign both the Newyears Green Bourne and River Colne. This will be carried out prior to the construction of these piers. The Newyears Green Bourne will be realigned to pass between the viaduct piers and new bends will be incorporated in the channel immediately upstream and downstream of the crossing. The River Colne will be realigned over the approach and exit sections to pass between the piers. During construction, local temporary widening will be required to mitigate the flood risk where pile caps extend under the active channel.

4.2.4 The realignments will be designed to ensure that the existing water quality, flow, sediment and hydro-morphological regimes are maintained and WFD issues are addressed, and are acceptable to the Environment Agency. Where practicable the new channel sections will be constructed in advance and will be allowed to stabilise and vegetation establish to control the risk of sediment mobilisation when the stream is actually diverted into the new channel cross sections. Where the objective, however, is to realign the channel through a crossing, or, having constructed a new channel cross section, to open it for flow, works will have to be undertaken in the existing channels in the approach sections to the crossing.

4.2.5 Given the scale of the work in the channels, mitigation will be incorporated to avoid major impacts during construction due to a temporary decrease in water quality. Prior to construction starting, a site specific risk assessment will be carried out as required by Section 16 of the draft CoCP. A method statement will be developed as required by Section 4 of the draft CoCP and agreed with the Environment Agency. The method statement will draw on the Environment Agency's *Works and maintenance in or near water*[11] *(PPG5)* as described in Section 16 of the draft CoCP. The types of appropriate mitigation to be considered will include the use of physical barriers such as bunds, booms or silt curtains and temporal considerations such as working at times of low flow or in drier conditions.

4.2.6 The management of water resource impacts will be fully integrated with those to manage impacts on the ecology of the rivers, as described in Volume 2, CFA Report 7, Section 7. As a result, it is anticipated that the water quality impact will, to the extent practicable, only depart from normal baseline values for short periods and even then the water quality will be similar to that typically achieved during flood events or normal maintenance.

[11] Environment Agency (2007) Works and Maintenance in or near water (PPG5), Available at: http://a0768b4a8a31e106d8b0-50dc802554eb38a24458b98ff72d550b.r19.cf3.rackcdn.com/pmho1107bnkg-e-e.pdf Accessed: 01/05/2013.

4.2.7 The crossing arrangements have been the subject of extensive discussions with the design team and with the Environment Agency in an effort to incorporate measures in to the design to minimise potential long term impacts on water quality, flow and hydro-morphological regime and address WFD issues. With the mitigation measures included in the design supported by pre- and post- construction monitoring and adherence to the requirements of the draft CoCP significant effects have been avoided.

4.2.8 Monitoring of the Newyears Green Bourne and River Colne will be undertaken in accordance with Section 16 of the draft CoCP to confirm that appropriate measures are effectively deployed according to a hierarchy to be agreed with the Environment Agency. This will reduce the magnitude of impact to negligible.

4.2.9 With implementation of the draft CoCP, the temporary construction effects have been assessed to be neutral and no further mitigation will be required.

Construction of piles, pile caps and viaducts in water bodies

4.2.10 Construction of the viaduct currently includes the need for piles and pile caps as foundations to those piers within water bodies as well as the viaduct superstructure above. A temporary jetty will be constructed alongside the route from which construction can be undertaken. A combination of surface casing and cofferdams will allow piling and pile caps to be completed without underwater excavation, and will minimise the potential for impacts on the remainder of the lakes being worked in.

4.2.11 Given the scale of the construction work, mitigation will be incorporated to avoid major impacts from a temporary decrease in water quality resulting from sediment, construction fluids or spills. Prior to construction starting, a site specific risk assessment will be carried out as required by the draft CoCP. A method statement will be developed as required by the draft CoCP and agreed with the Environment Agency. The method statement would draw on the Environment Agency's Works and Maintenance in or near water (PPG5) as described in the draft CoCP. The types of appropriate mitigation to be considered will include the use of physical barriers such as bunds, booms or silt curtains around the work areas.

4.2.12 The management of water resource impacts will be fully integrated with those to manage impacts on the ecology of the rivers and lakes, as described in Volume 2, CFA Report 7, the Colne Valley, Section 7. As a result, it is anticipated that the water quality impact will, to the extent practicable, only depart from normal baseline values for short periods and then towards levels typically achieved during flood events or normal maintenance.

4.2.13 Monitoring of the channels and lakes will be undertaken in accordance with the draft CoCP to confirm that appropriate measures are effectively deployed according to a hierarchy to be agreed with the Environment Agency. This will reduce the magnitude of impact to negligible.

4.2.14 With the implementation of the draft CoCP, the construction temporary effects have been assessed to be neutral and no further mitigation will be required.

Permanent drainage from the Colne Valley viaduct

4.2.15 Subject to detailed design, the permanent drainage of the Colne Valley viaduct has been assessed on a precautionary basis by considering that surface water drainage will comprise

longitudinal drains along the viaduct superstructure with outflows channelled down each viaduct pier. Drainage from each section of viaduct with a pier in a water body will thus discharge directly into the lakes or watercourse channel.

4.2.16 Since piers will be located at 40m intervals along the 14.3m wide viaduct, each pier's surface water runoff catchment will be approximately 572m^2. With an average annual rainfall of around 703mm/year in the Colne Valley, runoff from the viaduct has been estimated for each lake. The physical footprint of the structure over the existing water bodies is given in Table 8, with the covered area varying from less than 1% of Harefield Moor Lake, to approximately 30% of both the unnamed lake and the Long Pond.

4.2.17 The hydrology of the lakes will be unchanged where the viaduct intercepts rainfall that would otherwise have fallen onto the lake surface. The potential increase in runoff to each of the lakes, as a result of additional drainage catchment beyond the lake margins, has been considered. Total runoff to four of the lakes will be only marginally above natural levels, due to the maximum extension in the surface area of a lake's runoff catchment being only 572m^2. It is concluded that the viaduct will have negligible impact and a neutral effect on the hydrology of the lakes and the watercourses.

4.2.18 Surface water runoff from the track and viaduct superstructure is likely to contain higher concentrations of particulates as suspended solids and possibly some elevated levels of contaminants, including construction fluids or spills, compared to rainfall. There is therefore potential for impacts on water quality.

4.2.19 No data is available on the water quality of the future viaduct drainage during construction or operation. It is assessed that the water quality of drainage from a high speed railway will be better than low speed multi-use railways due to the absence of goods trains and the use of diesel powered engines being restricted to maintenance work. The surface water inflows and outflows are not known and may vary depending on whether direct connection to a watercourse exists. The potential impacts have therefore been assessed by calculating a potential dilution ratio.

4.2.20 The volume of runoff from the viaduct has been estimated for each lake. The lakes crossed by the viaduct range in volume from a 15,000m^3 unnamed lake (adjacent to Savay Lake) up to potentially 85,000m^3 in the Savay Lake itself. Three of the six lakes crossed are within the Mid Colne Valley SSSI.

4.2.21 Dilution ratios will vary between lakes with the greatest dilution in Harefield Moor of 0.073. Due to the relatively small volumes of runoff in relation to the volume of water in the Colne water bodies and the consequential dilution the impacts on water quality are likely to be negligible in Harefield No. 2, Savay, Korda and Harefield Moor lakes. In Long Pond and the unnamed lake, the smallest of the water bodies crossed by the viaduct, the dilution will be considerably less (dilution ratios around 0.4) leading to potentially minor impacts which gives rise to potentially moderate adverse effects.

4.2.22 While the likely chemical composition of the surface water runoff from the Colne Valley viaduct is not known, all discharges will be consented by the Environment Agency and therefore will meet legislative regulations for discharge into the environment.

4.2.23 The operation and management plan for water resources and flood risk (Volume 5: Appendix WR-001-000) sets out management measures for normal operation and

emergency response including pollution incidents. For protection of sensitive areas such as the Mid Colne Valley SSSI, and the SPZ associated with PWS, measures will be developed to minimise impacts from contaminated track runoff draining directly to the surface water receptors. These will include measures such as:

- controls on maintenance;
- controls on painting, track maintenance and the application of de-icing fluids and track grease; and
- a programme of monitoring and plan of actions to be taken by HS2 Ltd following an incident.

Highway drainage

4.2.24 As part of the Proposed Scheme two minor roads (Harvil Road and Tilehouse Lane) will be permanently realigned, Dews Lane and Chalfont Lane widened and new temporary roads constructed near the Chiltern tunnel main compound - temporary slip roads onto the M25 and a local route for through traffic while Chalfont Lane is closed.

4.2.25 The highway drainage for the temporary M25 slip roads will be integrated into the existing drainage and have negligible impact on water resources.

4.2.26 The SMR (see Volume 5: Appendix CT-001-000/1) and the SMR Addendum (see Volume 5: Appendix CT-001-000/2) state that a Design Manual for Roads and Bridges[12] (DMRB) (Department for Transport, 2013) Highways Agency Water Risk Assessment Tool (HAWRAT) assessment is required for realigned roads forecast to exceed both an average annual daily traffic (AADT) value of 10,000 and a heavy goods vehicles (HGV) value of 500. An initial desk study assessment has been carried out which will be further refined at the detailed design stage for the road realignments.

4.2.27 The following assumptions were made in order to carry out this initial assessment:

- the impermeable road area drained was estimated from satellite imagery and OS maps;
- the base flow index of the receiving watercourse has been taken as the HAWRAT default of 0.5; and
- a conservative river width of 1m was estimated from satellite imagery.

4.2.28 Harvil Road is forecast to experience AADT of HGV over 1,000 and an overall AADT in excess of 10,000. The HAWRAT assessment was undertaken for the realigned section of the Harvil Road assuming discharge into the Newyears Green Bourne which, in turn, discharges to the Harefield No. 2 Lake. HAWRAT Step 1 assesses the quality of the direct highway runoff against permissible threshold values - Harvil Road fails Step 1 for both pollutants copper and zinc and for sediment.

4.2.29 Step 2 is a refinement of Step 1, which accounts for the nature and diluting capacity of the receiving water body. Harvil Road passes the assessment on all accounts at Step 2. No adverse impact on water quality is foreseen therefore no mitigation is required.

[12] Department for Transport, (2013). Design Manual for Roads and Bridges: http://www.dft.gov.uk/ha/standards/dmrb/vol11/section3/hd4509.pdf

5 Site specific groundwater assessment

5.1 Summary of assessment

5.1.1 Table 9 summarises the potential impacts to hydrogeology (groundwater), abstractions, water dependent habitats and surface water/groundwater interactions. Only those impacts and effects that are classed as significant are presented in Volume 2, CFA Report 7, Section 13.4.

Table 9: Summary of potential impacts to groundwater receptors

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Hydrogeology (groundwater)									
Winter Hill Gravels	Low	Tilehouse Lane cutting	Some perched groundwater within the gravels could be drained by the cutting. The gravels however, are a low value receptor and spatially and vertically limited, as such there is unlikely to be a large volume of water intercepted by the cutting. These are also located above chalk and on a hill - so there is unlikely to be any groundwater in significant quantities in this receptor.	Minor impact Neutral effect (Not significant)	None required	Minor impact Neutral effect (Not significant)	None	Minor impact Neutral effect (Not significant)	Construction (permanent)
Superficial Secondary aquifers Chalk Principal aquifer	High	Colne Valley viaduct piers	Dewatering shallow groundwater during excavation for pile caps and all utility diversions below the watertable. Requirements for dewatering would be slight and short term but could have an effect on groundwater levels locally, particularly within the immediate area surrounding the pile caps and any deep utility diversions in the valley floor. As such there will be no significant effect to the wider hydrogeological regime.	Negligible impact Neutral effect (Not significant)	None required	Negligible impact Neutral effect (Not significant)	None required	Negligible impact Neutral effect (Not significant)	Construction (temporary)

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Chalk Principal aquifer	High	Colne Valley viaduct piers	Piling could create pathways between surface water or shallow groundwater and the Chalk aquifer, leading to contamination of Chalk groundwater.	Moderate impact Moderate effect (Significant)	Selection of piling methods for the viaduct piers and retaining walls will avoid creating hydraulic pathways, such as cracks and cavities between the construction and the natural rock and will be selected to avoid creating pathways between the aquifer and shallower surface water and groundwater.	Negligible impact Neutral effect (Not significant)	None required	Negligible impact Neutral effect (Not significant)	Construction (permanent)

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Chalk Principal aquifer	High	Colne Valley viaduct piers.	Existing pollution remediation abstractions (pump and treat) are evidence of existing groundwater contamination close to the route. Similarly there could be other potential sources of contamination, such as the former sewage treatment works at Denham Green. There will be the potential for piling activities or major excavation to cause dispersion or mobilisation of contamination.	Major impact Large effect (Significant)	Pre- and post-construction monitoring (as part of the requirements of the draft CoCP) will inform the extent of existing contamination and whether this could be mobilised or dispersed as a result of construction. Appropriate methods of construction will be developed to manage the risk of mobilising contamination. Therefore it is concluded that construction is unlikely to degrade groundwater quality as a result of existing pollution.	Negligible impact Neutral effect (Not significant)	None	Negligible impact Neutral effect (Not significant)	Construction (temporary)

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Chalk Principal aquifer	High	Colne Valley viaduct piers	Installation of piles could cause groundwater mounding due to groundwater flow being constricted between the pile groups beneath the viaduct. See detailed assessment Section 5.2 of this report for further details, which demonstrates that there will be negligible mounding.	Negligible impact Neutral effect (Not significant)	None required	Negligible impact Neutral effect (Not significant)	None	None	Not applicable
Chalk Principal aquifer	High	Piers for the temporary jetty.	Piles for the temporary jetty have been assumed to penetrate the top of the productive Chalk aquifer which will be the founding substrate. This reflects the scale of support required for this temporary structure. As such, the piles will not hinder groundwater flow to the same degree as the permanent piles for the viaduct, which will be installed deeper. There will be negligible impact on groundwater at the scale of the Mid Chilterns Chalk.	Negligible impact Neutral effect (Not significant)	None required	Negligible impact Neutral effect (Not significant)	None	None	Not applicable

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Chalk Principal aquifer	High	Chiltern tunnel arisings used for embankments. Sustainable placement of excavated material at South Harefield.	Deposition of embankment material may reduce groundwater recharge. The area for deposition of embankment material is, however, minimal compared to aquifer recharge areas.	Minor impact Moderate effect (Significant)	Rainfall will be collected by the route drainage systems and diverted to nearby ditches and swales. Infiltration through the ditches and swales will give rise to recharge close to the original rainfall location.	Negligible impact Neutral effect (Not significant)	None	Negligible impact Neutral effect (Not significant)	Construction (permanent)
Chalk Principal aquifer	High	Temporary stockpile of excavated material at the Chiltern tunnel south portal. Excavated material used for embankments. Sustainable placement of excavated material at South Harefield.	There is potential for constituents arising from the excavated material to reduce the quality of groundwater in the Chalk. See detailed assessment Section 5.2 of this report for further details.	Moderate impact Large effect (Significant)	Suitable quality criteria will be defined prior to material being placed. The draft CoCP (Section 15) defines the controls and guidance that should be followed in order to obtain agreement with the Environment Agency to obtain an appropriate permit or exemption from permitting. Monitoring water quality will also be implemented as outlined in the draft CoCP Section 16	Negligible impact Neutral effect (Not significant)	Not required	Negligible impact Neutral effect (Not significant)	Construction (Permanent)

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Abstractions									
PWS protected by SPZ, particularly TH177 and operated by Affinity Water	Very high	Colne Valley viaduct piers	The foundation piling may disrupt groundwater flow to abstractions that are particularly close to the route. The altered flow regime may reduce the source output. See detailed assessment Section 5.2 of this report for further details.	Major impact Very large effect (Significant)	Monitoring of yields and groundwater levels and quality will take place before, during and after construction until any impacts have stabilised to accepted levels. The monitoring data will be used to define appropriate mitigation, should it be required.	Major impact Very large effect (Significant)	Until a management strategy is agreed with the Environment Agency in consultation with Affinity Water, a potentially significant residual effect on the Affinity Water groundwater abstractions remains.	Major impact Very large effect (Significant)	Construction (temporary) and construction (permanent)

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
PWS protected by SPZ, particularly TH177 and operated by Affinity Water	Very high	Piers for the temporary jetty.	Piles for the temporary jetty have been assumed to penetrate the top of the productive Chalk aquifer at a shallower depth than those for the viaduct. As such there is unlikely to be a significant risk of disturbance to groundwater flow. Should flows be disturbed, the magnitude of effect and mitigation applied will be the same as for the permanent piers for the viaduct. See Section 5.2 of this report for further details.	Negligible impact Neutral effect (Not significant)	Monitoring of yields and groundwater levels and quality will take place before, during and after construction until any impacts have stabilised to accepted levels. The monitoring data will be used to define appropriate mitigation, should it be required.	Negligible impact Neutral effect (Not significant)	Mitigation will be applied for the permanent effect of the viaduct piers, if necessary.	Negligible impact Neutral effect (Not significant)	Construction (temporary)

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
PWS protected by SPZ TH171, TH177, TH174 and TH027, operated by Affinity Water	Very high	Chiltern tunnel Tilehouse Lane cutting Colne Valley viaduct piers	Potential to impact groundwater quality at the source as a result of turbidity, or fluids used in construction. See detailed assessment Section 5.2 of this report for further details.	Major impact Very large effect (Significant)	Implementation of the draft CoCP will ensure that materials in contact with groundwater will be selected and method statements developed to control any potential contaminants. Monitoring will take place before, during and after construction until the groundwater quality has stabilised. The monitoring data will be assessed and used to define appropriate mitigation, should it be required.	Major impact Very large effect (Significant)	Until a management strategy is agreed with the Environment Agency in consultation with Affinity Water, a potentially significant residual effect on the Affinity Water groundwater abstractions remains.	Major impact Very large effect (Significant)	Construction (temporary)

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Private licensed abstractions	High	Colne Valley viaduct piers	The foundation piling may disrupt groundwater flow to abstractions that are particularly close to the route. There are a total of 10 private licensed abstractions, and one unlicensed abstraction. GW25, GW27 and GW28 are the closest to the route (160-230m). Should important flow horizons be penetrated by the foundation piling for the viaduct, there is a slight possibility that the available yield at GW25, GW27 and GW28 could be reduced.	Moderate impact Moderate effect (Significant)	Monitoring of yields and groundwater levels to determine the potential impact. The monitoring schedule would include monitoring before, during and after construction until any impacts have been assessed. The monitoring data will be used to define appropriate mitigation, should it be required.	Moderate impact Moderate effect (Significant)	In the unlikely event that there is a significant impact on yields, long term options to provide alternative supplies will be agreed with the licensee.	Negligible impact Neutral effect (Not significant)	Construction (permanent)
Private licensed abstractions	High	Colne Valley viaduct piers	Potential to impact groundwater quality at private licensed abstractions, as a result of turbidity, or fluids used in construction. Foundation piling during construction of the viaduct may affect groundwater quality in abstractions that are particularly close to the route, most notably GW25, GW27 and GW28.	Major impact Large effect (Significant)	Monitoring to determine any impact. The monitoring schedule would include monitoring before, during and after construction until the groundwater quality has stabilised. The monitoring data will be assessed and used to define appropriate mitigation, should it be required.	Major impact Large effect (Significant)	Mitigation will comprise the provision of water from a public water supply source unless another alternative will also achieve negligible impact.	Negligible impact Neutral effect (Not significant)	Construction (temporary)

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Private licensed abstraction GW17	High	Tilehouse Lane cutting	The borehole used for the licensed groundwater abstraction at Tilehouse Lane lies within the land required for the construction of the Proposed Scheme	Major impact Large effect (Significant)	The asset lies within the land to be acquired for the Proposed Scheme. The borehole will be decommissioned and backfilled. An alternative supply or compensation will be provided. The impact on overall water resources will be negligible and not significant.	Negligible impact Neutral effect (Not significant)	Not required	Negligible impact Neutral effect (Not significant)	Construction (permanent)

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
PWS protected by SPZ TH177 and operated by Affinity Water.	Very high	Sustainable placement of excavated material at South Harefield	Excavated material, comprising up to 900,000m^3 of soil/rock from construction activity, will be placed near South Harefield. The site is approximately 885m north-east of TH177 and sits above half of the SPZ1 and half of SPZ2 that corresponds to TH177. There is potential for constituents arising from the excavated material to reduce the quality of groundwater in the Chalk. See detailed assessment Section 5.2 of this report for further details.	Moderate impact Very large effect (Significant)	Suitable quality criteria will be defined prior to material being placed. The draft CoCP (Section 15) defines the controls and guidance that should be followed in order to obtain agreement with the Environment Agency to obtain an appropriate permit or exemption from permitting. Monitoring water quality will also be implemented as outlined in the draft CoCP Section 16.	Negligible impact Neutral effect (Not significant)	Not required	Negligible impact Neutral effect (Not significant)	Construction (Permanent)

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
PWS protected by SPZ TH027 and TH171 and operated by Affinity Water.	Very high	Temporary stockpile at the Chiltern tunnel south portal	Impact to groundwater quality from deposition of temporary stockpile at the Chiltern tunnel south portal. No material or fluids will be placed in unlined lagoons See detailed assessment Section 5.2 of this report for further details.	Moderate impact Very large effect (Significant)	Suitable quality criteria will be defined prior to material being placed. The draft CoCP (Section 15) defines the controls and guidance that should be followed in order to obtain agreement with the Environment Agency to obtain an appropriate permit or exemption from permitting. Monitoring water quality will also be implemented as outlined in the draft CoCP Section 16.	Negligible impact Neutral effect (Not significant)	Not required	Negligible impact Neutral effect (Not significant)	Construction (Temporary)

Receptor	Receptor value	Design element	Discussion of potential impact to water receptor	Magnitude of potential impact	Avoidance and mitigation measures included in design	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Surface water/groundwater interaction									
Lakes comprising the Mid Colne SSSI and other lakes in the Colne Valley	Very high and high	Colne Valley viaduct piers	Gravel deposits form a shallow aquifer across the valley floor. The lakes occur where these gravels have been excavated. Any potential changes to the groundwater levels and quality in the gravels, as a result of the construction of the piers, may therefore impact the surface water quality and levels and subsequently effect local ecology within the SSSI and adjacent lakes. Natural attenuation (settlement, filtration, dispersion, diffusion and dilution) will reduce any turbidity resulting from construction to levels that are unlikely to significantly affect surface water quality.	Minor impact Moderate effect (Significant)	With implementation of the draft CoCP measures, shallow groundwater quality and flow is unlikely to be significantly impacted by construction in this area.	Negligible impact Neutral effect (Not significant)	Not required	Negligible impact Neutral effect (Not significant)	Construction (temporary)

5.2 Detailed assessments

Impact to groundwater flow from piling for viaduct piers

5.2.1 A simple conceptual approach based on an assumption of uniform aquifer properties allows a conservative assessment of the permanent impacts from piling to be completed. Flow to a borehole is governed by three factors:

- the hydraulic gradient under which flow will occur, which increases when pumping commences and which is calculated as the change in groundwater level (dh) over a specific distance (dl) and is defined as 'dh/dl';
- the permeability (commonly indicated as 'k') of the formation providing the water (the Chalk in this case); and
- the cross-sectional area of aquifer through which groundwater can flow. The cross-sectional area is defined by the thickness of the aquifer (commonly indicated as 'b') and the width of the catchment supplying water to the borehole (commonly defined 'w').

5.2.2 Flow to the aquifer is represented by Darcy's Law:

Flow (Q) = -k x b x w x dh/dl

5.2.3 The Colne Valley viaduct construction will comprise a number of piers and supporting piles at approximately 40m spacing. The piling depth is anticipated to be 20-40m and as such the piles will penetrate the top of the Newhaven and Seaford Chalk aquifers. The piles could locally block groundwater flow that may in turn affect the operation of PWS abstractions, such as TH177 which will be in close proximity to the route. Figure 4 illustrates the pile cap construction through the Chalk aquifer system.

5.2.4 Geophysical information available for different boreholes in the Chalk in the Colne Valley indicates that the formations present could include at least three flow horizons at 14-16m BGL, 26-32m BGL, and 48-52m BGL. The information available does not indicate whether these flow horizons are present over a wide lateral area, or how connected they are, but they will be acting as principal flow zones where they exist.

5.2.5 Groundwater flow within the vicinity of the viaduct is generally from north-west to south-east, parallel to the route. Abstraction from each of the PWS will create a cone of depression around the source boreholes. In homogenous conditions an abstraction borehole would induce radial flow to the point of abstraction. In the case of the source protected by SPZ TH177, half of the groundwater flowing to the abstraction will be from the east, north-east and south-east and the other half from the west, north-west and south-west. The groundwater movement to the borehole however is strongly influenced by the regional hydraulic gradient and most of the water abstracted from the PWS will be obtained from up-gradient of the borehole (i.e. to the north-west).

5.2.6 The route will intersect the borehole's catchment to the south-west of the abstraction (i.e. the route is down-gradient of the abstraction) and as such, groundwater flow to the PWS protected by SPZ TH177 from the up-gradient areas will not be affected, only flow from the area down-gradient of the source protected by SPZ TH177 will be

reduced. Figure 5 illustrates the approximate flow zones surrounding the abstraction that could be affected by the piles.

5.2.7 The viaduct's supporting piers will be at 40m spacing with a 15m by 15m pile cap under each pier. Each pile cap would contain nine piles in a three by three layout, with approximately 14m width being largely impermeable. The piles will be installed to an assumed depth of up to 40m. For the purpose of this conservative assessment the piles are assumed to completely obstruct groundwater flow over a 14m section in every 40m width of aquifer (the pile cap is assumed to extend 0.5 m beyond the piles), as demonstrated in Figure 4. In practice, some flow may continue beneath the toes of the piles, or between the individual piles under a pile cap.

5.2.8 The assessment of impact to flow considers uniform radial flow to a nearby groundwater abstraction, which provides an indication of the worst case impact expected from the piles. The original width accounting for flow to the groundwater abstractions is taken to be w_o, with flow through that width following Darcy's Law and being dependent on k, dh/dl, w_o and b. The piles will effectively reduce the width available for flow (w_r) by 35%. By reducing the width available for flow, the flow to the abstraction will also reduce in proportion of the reduction in width. Figure 5 shows a schematic representation of flow to the abstraction together with the two halves of the capture zone of flow to the abstraction, assuming radial flow.

Figure 4: Schematic diagram illustrating the pile cap construction and effect on groundwater flow

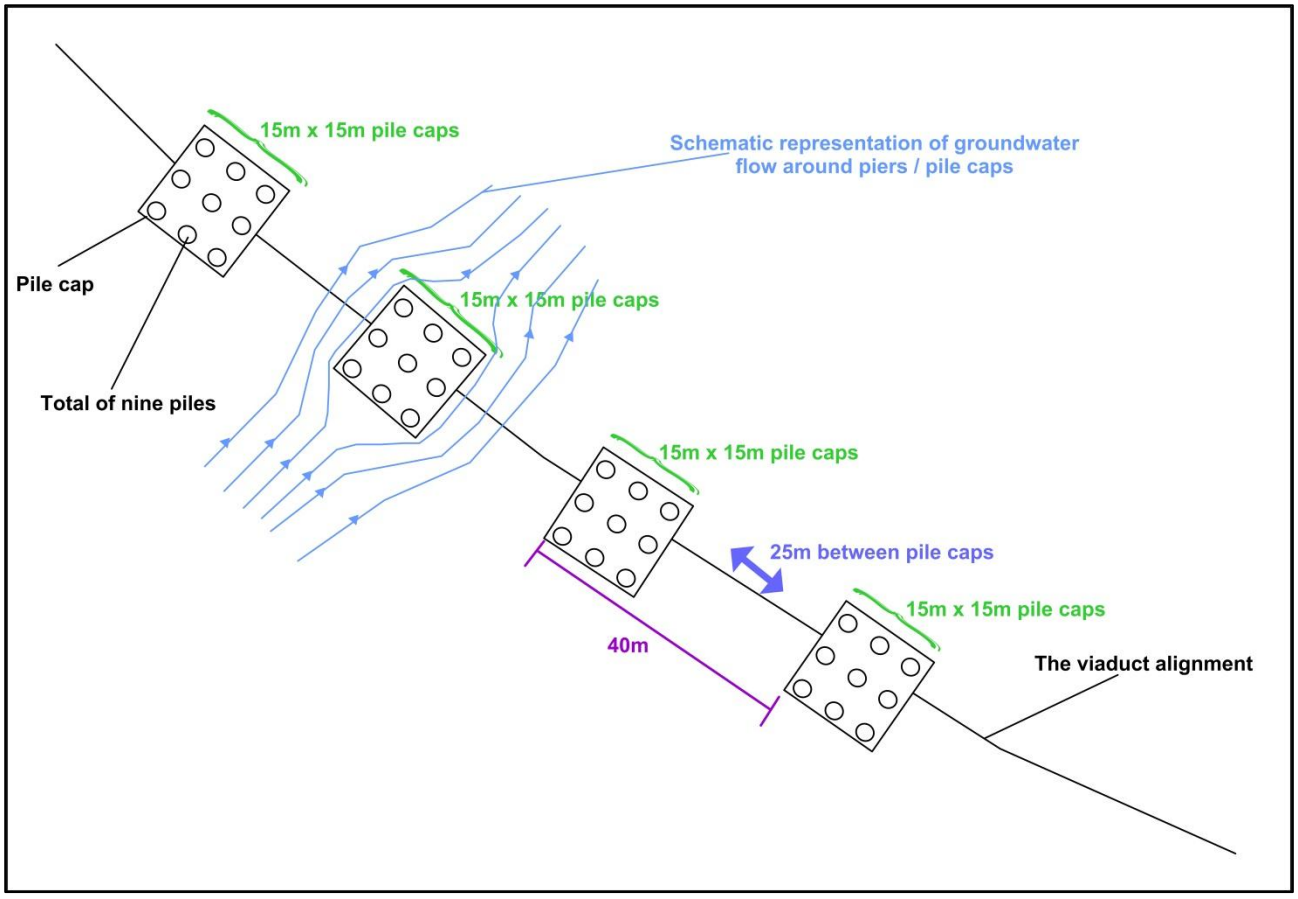
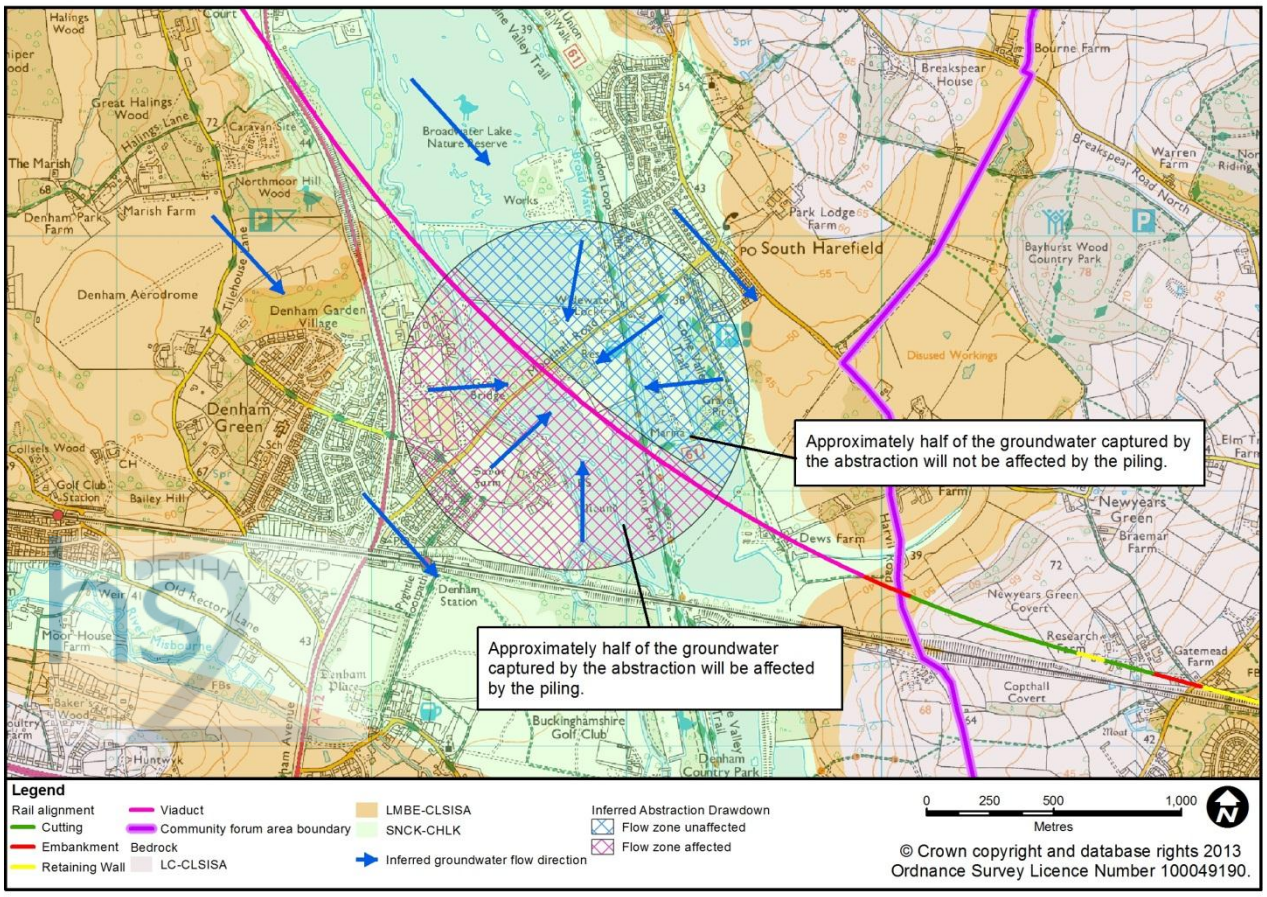


Figure 5: Schematic representation of effect on transmissivity caused by the piers[13]



5.2.9 With regard to the effective flow to the abstraction, the effect of piling will only reduce flow to the abstraction from the south-western half of the capture zone - in other words the flow to the abstraction that will need to pass through the area of piling. Flow from the north/north-west will be unaffected. As such the reduction in flow will not be as great as 35% but will be approximately half that, i.e. 17.5%. Due to the almost linear relationship between flow rate and drawdown (as set out in Darcy's Law) for a given flow rate, the drawdown at a PWS would increase by up to 17.5% to account for a reduction in width and effective flow to the abstraction (assuming the catchment area did not increase in area to compensate which is quite possible). Alternatively, to maintain a given drawdown, the discharge at the PWS would be reduced by up to 17.5%.

5.2.10 It is important to note that this estimated impact is a conservative assessment under a series of significant assumptions including:

- the aquifer is homogenous - it is likely that actually there will be enhanced transmissivity in the Chalk in the valleys where the abstractions are located compared to the surrounding hills and this would reduce the predicted effects on flow and drawdown;

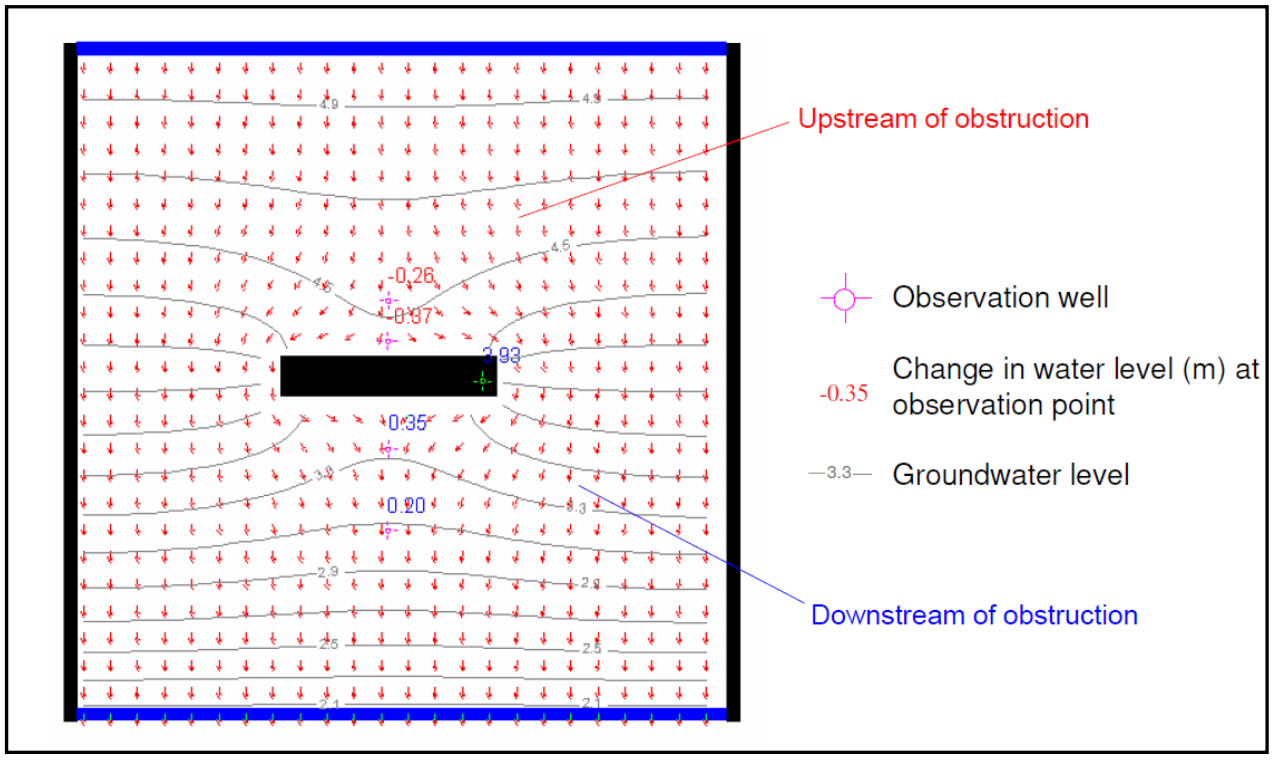
[13] Key to legend geological formations: LMBE-CLSISA = Lambeth Group, SNCK-CHLK = White Chalk Subgroup.

- uniform groundwater flow is occurring - this is not likely to be true and more flow will be obtained from up-gradient (i.e. from areas not affected by piling for the route); and
- all piles extend to the anticipated maximum depth - in reality some piles will not have to extend to the full 40m depth and there will be some flow in between piles in places.

5.2.11 Another means of assessing the impact of partial barriers to flow was completed for the Crossrail Environmental Statement (Mott MacDonald, 2005[14]). An analogue model was created to look at the impact of a rectangular obstruction in an aquifer, and how this affects flow in the aquifer. Not surprisingly the results showed that the effect of an obstruction of limited extent in the direction of groundwater flow reduces both with the size of the obstruction and its distance from the source. Maximum water level changes occur immediately upstream and downstream of the obstruction, and flow will redistribute around an obstacle placed in the area of groundwater flow.

5.2.12 Figure 6 shows the results of the modelling of an obstruction, with the impact on groundwater levels reducing further upstream and downstream. In this example, an obstruction of dimensions 80m by 15m results in a reduction in the width of flow of approximately 30%.

Figure 6: Groundwater flow and level changes around an obstruction

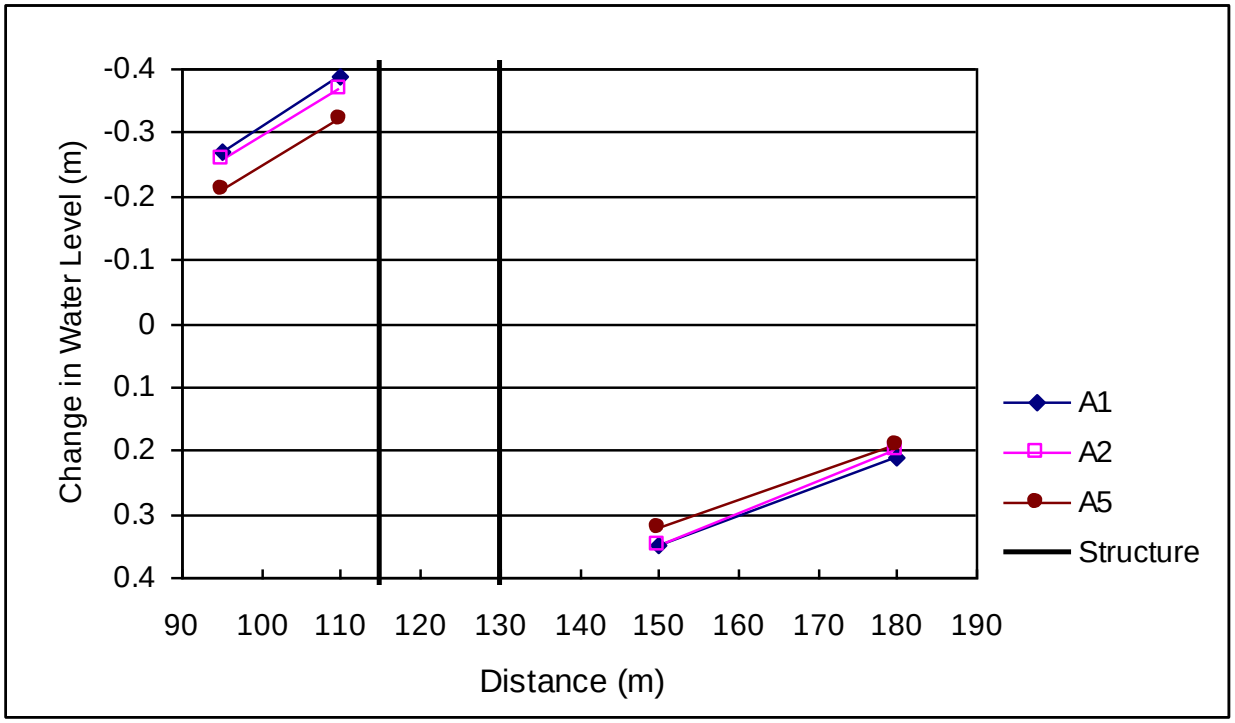


5.2.13 The simulated water level changes occurring at different distances from the structure in Figure 6 had also been considered. The simulated fall in water level 50m from the

[14] Mott MacDonald (2005). Crossrail Line 1; Assessment of Water Impacts Technical Report. Appendix E: Analysis of Impacts on Groundwater. Ref: 203357/31/Final/February 2005.

downstream face of the structure is 0.2m, and at 20m downstream is 0.35m. By extrapolation, the impact on the immediate downstream face of the obstruction is of the order of 0.4m which reduces by around 25% at a point 25m from the downstream face or 50% at a point 50m away. Simulated changes in groundwater levels are shown on Figure 7, where three different sets of hydraulic parameters have been applied (A1, A2 and A5). Groundwater flow is from left to right.

Figure 7: Change in groundwater levels up-gradient (left) and down-gradient (right) of the obstruction



5.2.14 Since the model is inherently scalable, it is concluded that the water level impact near a Colne Valley viaduct pier will reduce by at least 25% at a distance of 25m downstream from a pile cap, compared to that at the pile cap. With consideration of the potential reduction in flow and drawdown of 17.5% at TH177 calculated above, and assuming that the actual reduction could be 25% lower, an estimation of approximately 13% would therefore be a more likely estimate than 17.5 % at a source around 25m from a pile cap. The impact is likely to be further reduced for each of the more distant pile caps.

5.2.15 It is concluded that piling for the viaduct piers could disturb the groundwater flow regime to PWS protected by SPZ TH177 since this will be particularly close to the route. Should principal groundwater flow horizons be penetrated there could be a permanent reduction in yield at the PWS. The groundwater flow and, hence, the yield at the PWS source could be reduced by between 13 and 17.5%, based on the underlying assumptions discussed herein. The reduction in yield will give rise to a major impact on this very high value receptor, leading to a very large and significant effect.

5.2.16 The effect of piling on the yield at PWS source protected by SPZ TH177 will be the subject of an appropriate water management plan to be developed by HS2 Ltd in

agreement with the Environment Agency and in consultation with Affinity Water. Mitigation will be in place to ensure supplies to customers are not affected.

5.2.17 The PWS protected by SPZ TH027 is over 300m from the viaduct and the effect of piling on the pumping water level has been calculated assuming a 35% reduction in available flow (as calculated above). Similar to the assessment for TH177, only flow to the abstraction from the west and south-west will be reduced as a result of piling and as such the reduction in flow/drawdown would be approximately 17.5%. Following the scalable impact depending on the distance of the abstraction from the obstruction (as shown in Figure 7), this would indicate that the impact on water levels at 300m from the piles would be reduced to such an extent that the change to the existing levels would be negligible. The impact on pumped water levels in the source protected by SPZ TH027 would therefore be not significant.

Impact to groundwater flow from piling associated with the temporary jetty

5.2.18 Piles for the temporary jetty have been assumed to penetrate the top of the productive Chalk aquifer which will be the founding substrate. This reflects the scale of support required for this temporary structure. As such, the piles will not hinder groundwater flow to the same degree as the permanent piles for the viaduct, which will be installed deeper.

5.2.19 The information available indicates that there are three principal flow horizons in the Colne Valley at which depths the majority of flow in the Chalk will occur. These depths are at 14-16m BGL, 26-32m BGL and 48-52m BGL. Whilst there will be some variation in the exact depth, depending on the location within the valley, it can be assumed that there is one flow horizon above 20m, one between 20 and 30 and one deeper below 45m.

5.2.20 It is assumed that the temporary piles will be approximately 20m deep and that they will intersect the flow horizon at 14-16m BGL, where this exists. Flow will not, therefore, be affected in the deeper flow horizons which will continue to provide flow to PWS, such as that protected by SPZ TH177. Most of the abstraction boreholes themselves will be cased off, effectively sealing the borehole against water ingress, in the upper 20m BGL, as a hygiene seal. The shallower flow horizon therefore is unlikely to currently provide substantial flow to the abstraction.

5.2.21 The temporary jetty itself also stops about 150m either side of the source protected by SPZ TH177, so there would be no immediate blockage closest to the source.

5.2.22 In conclusion, the impact from the temporary jetty is unlikely to be worse than that for the main viaduct piers and the assessment and mitigation applied for the permanent effects from the viaduct piers will be protective of any impacts caused by the temporary piles for the jetty.

Impact to groundwater quality from piling and tunnelling

5.2.23 Underground works including tunnelling, piling and construction of diaphragm walls can affect groundwater quality where the works are carried out in a formation with hydraulic connection to an aquifer, or in the aquifer itself. Underground works in the

Chalk can have a direct impact on any nearby groundwater sources. The main issues are considered to be losses of circulation fluid, turbidity resulting from the breakdown of in-situ aquifer material, and possible contamination by hydraulic fluids and greases from machinery. There is likely to be a more rapid transfer of these materials through fractures in the Chalk. Where such movement occurs in the catchment supplying a PWS source then the degraded groundwater quality may make the source unsuitable for potable use. Such catchments are indicated by the SPZ1 and SPZ2 areas defined by the Environment Agency around all PWS.

5.2.24 The potential impacts from the construction by diaphragm walling and tunnelling is mitigated by the ability to add bentonite and other conditioners to reduce fluid loss in circulation or grouting fluids, by increasing viscosity and gel properties. Injection fluid pressures will also be regulated in closed face tunnelling in order to reduce any losses.

5.2.25 Piling can be mitigated by using bentonite in the process to reduce fluid loss. Many methods of piling can also be facilitated by the use of temporary casing, which is generally more useful to stop losses to immediately adjacent watercourses.

5.2.26 Implementation of the draft CoCP will ensure that materials in contact with groundwater will be selected, and method statements developed, to control any potential contaminants. Monitoring will take place before, during and after construction until the groundwater quality has stabilised to levels agreed with the Environment Agency. The monitoring data will be assessed and used to define any additional appropriate mitigation, should it be required.

5.2.27 Nonetheless, there is a substantial residual risk that the groundwater quality at any abstraction sources located close to underground works could be affected by circulation fluid, turbidity or possibly contamination from boring machinery. The location of greatest concern is the Affinity Water PWS source TH177, located very close to the viaduct piers and associated piles. The impact on this very high value receptor is potentially major if there are significant fractures linking the pier locations and the abstraction site, this will be likely to give rise to a very large effect.

5.2.28 The measures necessary to mitigate any temporary effect of piling on the groundwater quality at TH177 and other PWS sources will be agreed with the Environment Agency in consultation with Affinity Water.

5.2.29 For private licensed abstractions at significant risk due to underground works, provision of alternative temporary supplies will be agreed with the licensees if this is necessary.

Impact to groundwater from cuttings

Tilehouse Lane cutting

5.2.30 A summary of the cutting details are provided in Table 10.

Table 10: Summary of Tilehouse Lane cutting detailed groundwater assessment

Cutting parameters	Parameter details
Length (km)	0.25
Maximum depth (m)	10.8
Strata intercepted	Winter Hill Gravel (Secondary A aquifer) Lambeth Group (Secondary A aquifer) Newhaven and Seaford Chalk Formations (Principal aquifer)
Lowest track level (m AOD)	54.7
Groundwater level(s) (m AOD)	42 – 43 (in Chalk)
Principal receptors	Groundwater in the Chalk aquifer TH177 and Th027 PWS abstraction

5.2.31 The cutting would penetrate the Chalk aquifer in an area where the maximum recorded groundwater levels are approximately 11m below the cutting. Groundwater flow will therefore not be disrupted. The residual thickness of unsaturated zone will provide some attenuation of seepage from the cutting. Application of the draft CoCP will ensure materials and fluids used during construction are managed so that there is no significant adverse effect on groundwater quality.

Chiltern tunnel south cutting

5.2.32 A summary of the cutting details are provided in Table 11.

Table 11: Summary of Chiltern tunnel south cutting detailed groundwater assessment

Cutting parameters	Parameter details
Length (km)	0.18
Maximum depth (m)	14.5
Strata intercepted	Gerrards Cross Gravel (Secondary A aquifer) Newhaven and Seaford Chalk Formations (Principal aquifer)
Lowest track level (m AOD)	57.1
Groundwater level(s) (m AOD)	49 (in Chalk)
Principal receptors	Groundwater in the Chalk aquifer TH177 and Th027 PWS abstraction

5.2.33 The cutting would penetrate the Chalk aquifer, but maximum recorded groundwater levels in this area are approximately 8m below the cutting. Groundwater flow will not be disrupted. The residual thickness of unsaturated zone will provide some attenuation of seepage from the cutting. Application of the draft CoCP will ensure

materials and fluids used during construction are managed so that there is no significant adverse effect on groundwater quality.

Impact to groundwater quality from South Harefield sustainable placement area

5.2.34 Excavated material, comprising up to 900,000m^3 of soil and rock from construction activity will be placed near South Harefield. The site sits above half of the SPZ1 and half of SPZ2 that protect TH177. As such, there will be potential for constituents arising from the excavated material to reduce the quality of groundwater in the Chalk which could impact the operation of the source within SPZ TH177.

5.2.35 The site lies above the Lambeth Group which in turn lies above the Chalk. British Geological Survey (BGS) borehole logs are available for boreholes in the vicinity of Dewes Farm which is just south of the sustainable placement area. The logs indicate the presence of a soft sandy clay to a depth of 3.4 - 6.1m BGL, with the water strike at 1.5 - 2.1m BGL. As such, it is reasonable to assume there will be approximately 5m of a low permeability silty clay layer above the Chalk which will hinder downward migration of water. Notwithstanding this, the Lambeth Group is itself classified as a Secondary A aquifer and it will be in hydraulic connectivity with the underlying Chalk Principal aquifer. Groundwater levels are relatively close to the surface so there will be a limited thickness of unsaturated zone to attenuate the migration of constituents to the water table.

5.2.36 Suitable quality criteria will be defined prior to material being placed. The draft CoCP (Section 15) defines the controls and guidance that will be followed in order to obtain agreement with the Environment Agency to obtain an appropriate permit or exemption from permitting. The criteria will be determined to ensure that there is no significant degradation to groundwater quality as a result of the placement of material. The criteria will be agreed with the Environment Agency before placement of the material. The management of the material will be in accordance with the Contaminated Land: Applications in Real Environments (CL:AIRE) Definition of Waste: Development Industry Code of Practice[15] (as stated in the draft CoCP).

5.2.37 The compliance criteria will also provide a further level of security to protect groundwater quality by taking account of the source material, the amount of infiltration to the stockpile or percolation under the stockpile and the drainage design for the stockpiles.

5.2.38 The material deposited on the site will be that excavated for the West Ruislip siding. It will largely comprise London Clay and, as such, is unlikely to contain constituents that will adversely affect the groundwater quality. The material excavated from the West Ruislip siding will not contain made ground and is considered to be clean, inert material.

5.2.39 If the permeability of the clay material is lower than the existing surficial strata there will be a reduction in recharge to the underlying strata. The area covered, however, is

15 Contaminated Land: Applications in Real Environments (2011) The Definition of Waste: Development Industry Code of Practice (Version 2, March 2011).

small compared to the overall area of recharge and unlikely to significantly affect the total water balance of the Chalk aquifer.

Impact to groundwater quality from deposition of temporary stockpile at the Chiltern tunnel south portal

5.2.40 The majority of arisings from the construction of the Chiltern tunnel and portal will be temporarily deposited on landscaped areas to the south of the Chiltern tunnel portal construction site. The deposition area is approximately 100m south of the route and comprises an area of approximately 514,000m^2. The southern half of the site has the Lambeth Group at the surface, whereas the northern half has the Newhaven and Seaford Principal Chalk aquifers at the surface. The groundwater table is likely to be approximately20m BGL at the site, providing a protective 20m of unsaturated Chalk about the water table.

5.2.41 The large majority of the stockpiled area sits within the SPZ1 identified as TH027 with about 60,000m^2 within the SPZ2. As such, there is potential for groundwater quality to be adversely affected which could impact on the use of the source within TH027, particularly if there are fast pathways and fissures to the Chalk water table.

5.2.42 During construction, the fluids arising from the tunnel boring machine (TBM) process will be removed from excavated materials using a centrifugal process and the remaining arisings will be pressed to further reduce the liquid content. No arising material or fluids will be placed in unlined lagoons.

5.2.43 Suitable quality criteria for the material placed in the temporary stockpile will be defined prior to material being placed. The draft CoCP (Section 15) defines the controls and guidance that will be followed in order to obtain agreement with the Environment Agency to obtain an appropriate permit or exemption from permitting. The criteria will be determined to ensure that there is no significant degradation to groundwater quality as a result of the placement of material. The criteria will be agreed with the Environment Agency before placement of the material. The management of the material will be in accordance with the CL:AIRE code of practice (as stated in the draft CoCP).

5.2.44 The material deposited in the temporary stockpile is considered to comprise natural chalk material excavated during the construction of the tunnel and portal and as such is unlikely to contain constituents that will adversely affect the groundwater quality. Consequently, it is considered as a generally clean, inert material. Notwithstanding this, the compliance criteria will provide a further level of security to protect groundwater quality since there will be small amounts of artificial materials remaining after centrifuging. These could comprise bentonite, polymers and other soil conditioners/plasticisers or trace amounts of hydraulic oils and greases. The compliance criteria will take into account the amount of infiltration to the stockpile or percolation under the stockpile, site drainage design and the concentrations likely to be present in the arising. Further treatments such as lime stabilisation may be applied, depending on the eventual end use of the material.

5.2.45 Taking account of the inert nature of the arisings and the strict compliance criteria to be developed it is concluded that there will be a negligible impact on groundwater quality in the SPZs and a neutral effect. Specific monitoring to determine the potential impact to PWS (Affinity Water) will be undertaken. The monitoring schedule (to be agreed with the Environment Agency and in consultation with Affinity Water) will include monitoring before, during and after construction until the groundwater quality has stabilised (within acceptable limits). The monitoring data will be assessed and used to define appropriate mitigation, should it be required.

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